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DETERMINING THE USABILITY OF DIGITAL VIDEO INTERACTIVE (DVI) TECHNOLOGY IN COMPUTER-BASED INSTRUCTION

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The use of advanced multimedia technologies can enhance computer-based instruction (CBI). This research sought to understand the usability of digital video interactive (DVI) for Air Force instructional designers. Findings were expanded to include the development of a model for multimedia development. Task analysis and process description data are also provided. Findings were that DVI technology is very difficult to use and AF users will better be able to employ software multimedia packages currently available. The multimedia development model developed during this project uses job, task, and observational data to provide process descriptions of multimedia development relying on the ISD model as the overall support structure. It is highly recommended this model be validated and automated for use by Air Force CBI developers.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

Research to determine the usability of DVI technology in computer-based instruction forms a portion of a larger research and development (R&D) program being conducted by the Instructional Design Branch (AL/HRTC) of the Technical Training Research Division, Human Resources Directorate of the Armstrong Laboratory. R&D by this branch has investigated the potential for providing guidelines, authoring assistance and automated tools to Air Force instructional developers. This project provides some lessons learned in the application of a rapidly evolving technology to typical Air Force instructional design problems. The results are already being applied in continuing research applications.

When this project began, multimedia technology in general (both software and hardware), and DVI specifically, was changing rapidly. Software tools were being developed by several vendors. The research team knew that even though some products were not complete the project had to begin. As a consequence, several decisions were made early in the project which directed its course. These decisions centered around a probable typical Air Force multimedia delivery platform of the future being a 3/486 processor, relatively large hard disk (>500MB), optional CD-ROM, Windows-based machine. These assumptions influenced the choices made throughout the study. Within 6 months of beginning this project the researchers realized that the initial goal of the study, i.e., to determine the applicability of DVI technology to computer-based training was too limited. Developments were taking place in the marketplace which permitted software driven digital video capture, editing and replay in the Windows environment. Therefore, the research team expanded the research effort to include looking at this technology. Results are included in this report.

Special thanks from the entire research team must be extended to Lt.Col. James Mohan of the 338th Operations Training Squadron, Air Training Command, who served as the principal subject matter expert (SME) for this project. Lt. Col. Mohan not only provided the required formation flying expertise necessary to produce accurate lessons; at times he was part of the research team, discussing problems associated with hardware or software, offering instructional systems design recommendations, and providing insights into what would and would not work, thereby saving the development team many long hours of trial and error. He was a welcome and active participant at all meetings, providing helpful comments to the development team members, yet maintaining his role as the principal SME.

We would also like to thank Capt. John O'Connell of the 338th Operations Training Squadron, who provided additional expertise in formation flying. Video editing equipment and services were provided by Alejandro Maya of VideoWave Productions.

SUMMARY

Multimedia technology and Digital Video Interactive (DVI) in particular are maturing visualization technologies which hold promise as powerful tools for Air Force instructional developers. The difficulty with multimedia is that it requires expertise in several specialties to work with it effectively. Few Air Force instructional developers or instructional development shops possess the skills needed to integrate multimedia into training applications. This research project examined the roles of a multimedia development team to determine the required functions, activities and tasks performed, and the skills and knowledge which support performance of such tasks.

As part of the research, several prototype multimedia interactive courseware lessons were developed to demonstrate multimedia development and production activities. The original focus of the project was to determine the usability of DVI technology in computer-based training, however, the development team also examined other software packages which performed similar functions. Thus the focus was broadened to include multimedia rather than only DVI.

An observational study was conducted during the entire multimedia development project. During the observations, critical incidents which had an impact on the project were identified. Results of the observations were also used to debrief the multimedia expert and team members. A task analysis hierarchy was constructed describing multimedia development activities. The observations and task hierarchy formed the basis for development of a model of the multimedia development process. While the model can stand alone as a description of multimedia development, it should be considered the first step at formulating principles and guidelines for multimedia development. The model also serves a second purpose as the basis for identifying components of the multimedia process which can be automated. In the future, inclusion of visualization technologies such as multimedia into automated systems such as the Automated Instructional Design Advisor (AIDA) will encourage the effective use of such powerful technologies to support sound instructional design.

DETERMINING THE USABILITY OF DIGITAL VIDEO INTERACTIVE (DVI) TECHNOLOGY IN COMPUTER-BASED INSTRUCTION

I. INTRODUCTION

Armstrong Laboratory has been conducting research into the simplification of the instructional design process for several years (Kintsch, E., Tennyson, R. D., Gagn'e, R., & Muraida, D. J. (1991); Polson, M. E., Polson, P. G., Kieras, D., Jalff, J., & Hioki, R. (1992), Tennyson, R. D., Reigeluth, C. R., & Gettman, D. J., (1992). Computer-Based Training (CBT) including some form of multimedia is a powerful tool when designed and implemented by a trained instructional developer. However, the availability of skilled instructional developers in the Air Force is limited. Traditionally, the Air Force relies on a few instructional developers to assist many subject matter experts (SMEs) to develop all kinds of training. Although fully qualified in their areas of expertise, SMEs rarely possess both adequate instructional design knowledge and the various computer skills required to develop an effective training system. If tools were available to assist the instructional designer, i.e. *clone* the expert instructional designer, more high quality CBT could be produced faster and cheaper than with current practices. The Laboratory's work on projects such as the Automated Instructional Design Advisor (AIDA) is on the verge of providing a breakthrough in the area of such instructional design tools. What is also needed is the ability to integrate the highly creative capability of multimedia into systems such as AIDA. This will require identifying and capturing the instructional design and technical expertise associated with multimedia and ensuring that this expertise is also built into AIDA.

This study used direct observation methods, job and task analysis, and structured interview techniques to examine the process of developing a multimedia prototype training system. The purpose of using observational methods was to formulate a conceptual model of the multimedia development process to serve as a basis for integrating research findings with computer-based courseware authoring aids such as AIDA. Hypotheses were proposed concerning the critical information about multimedia development required by Air Force SMEs. The study also identified critical activities and development team interactions required to produce cost-efficient and effective training courseware.

Background

Multimedia platforms, including interactive videodisc, digital video, and specific products such as Digital Video Interactive (DVI) are becoming more widely used. The goal of these multimedia delivery systems is to take advantage of the integrated interface and interactive opportunities which involve the student in an environment which is as close as possible to the context in which learning will be applied. However, exceptionally well analyzed and professionally prepared implementation of multimedia technologies are not often replicated in typical instructional settings. Two possible reasons for this problem have to do with the availability of well-documented and compatible software products, and the relative difficulty of learning to effectively use multimedia tools to enhance sound instructional design.

Purpose

In keeping with Armstrong Laboratory's long history of developing automated instructional design tools, AIDA will provide typical Air Force SMEs, i.e., inexperienced instructional designers, with the necessary tools to assist them in producing consistently high quality and less costly courseware by providing intelligent frameworks appropriate for a variety of training settings. The AIDA tool kit can be enhanced by including visualization technologies such as multimedia, which has the ability to produce highly realistic job-like simulations. The primary objective of the current study was to investigate the multimedia development process, specifically DVI, in order to extract general procedures, guidelines, and techniques which could be used by: 1) Air Force instructional developers/SMEs required to perform multimedia tasks, and; 2) software designers of computer-based courseware authoring aids such as AIDA. This study examined the multimedia development process in detail to identify those activities, tasks, tools, and other elements such as hardware and software selection, specific to the training medium which can be modeled. Applications of these results will provide a framework for demonstrating to novice instructional developers the proper developmental context and utilization of the medium, and identify for software developers unique multimedia characteristics which can be successfully integrated into tools such as AIDA.

Approach

This study began with a comprehensive review of the literature in three primary areas: 1) observational methods; 2) problem-solving research, and; 3) multimedia development. Additionally, the status of various emerging training technologies were reviewed. The approach was guided by three general principles. First, since this was an exploratory research project, it emphasized collecting basic data on the rapidly evolving topic of multimedia development. Second, certain observational methods, such as the critical incident technique, were suggested by the Laboratory in part to try them out for future, more intensive studies of developmental processes. Finally, the cognitive relationships of instructional design to multimedia development were evaluated in terms of their inputs, processes, and outputs for modeling training system development (Spector, Muraida, & Marlino 1992).

Observational Research

Observational research is often conducted to obtain background data for understanding behavior and performance or to formulate an initial conceptualization of the problem domain. Traditional direct observational methods are used in psychological, anthropological, educational, and consumer research. They usually involve minimal interference with the subject's behavior and environment. Traditional observational data, often described as "field notes," usually consist of two parts-- description and reflection. *Description* includes details about the subject, setting, accounts of particular events and activities, and relevant dialog. *Reflection* can contain preliminary analysis, decisions about methods, actual or potential conflicts, and points of clarification (Bogdan & Biklen 1992).

There are several limitations inherent in observational research. First, it is basically a subjective method, involving individual perception and judgment. Second, the mere presence of an observer may have an affect on subjects' behaviors. Third, a variety of observational errors can occur, including: loss of detail through simplification, stereotyping and prejudice, preference for familiar behaviors, and misinterpreting or second-guessing the thoughts or motives of subjects (Meister 1985). It is also more difficult to observe, in real-time, a group of individuals rather than just one person. These kinds of factors and errors can have multiple effects on the research data collected, although these are typically hard to validate (Kirk & Miller 1986). Fourth, interpretation of observations can be problematic. Finally, reliability is often an issue in observational studies, however, since the current research study was a pilot project and there was only one observer, no tests of reliability were conducted.

The structured or informational interview is a technique which was also used to obtain information during the multimedia development process. According to Meister (1985), it can help to evaluate the subject's: 1) internal processes, e.g., what he or she thinks he or she is doing; 2) knowledge of how a job is performed, and; 3) perception of external events. Questions must be clear and concise, although the interview may be informally conducted, e.g., questions can lead to unplanned but relevant topics.

Problem Solving Research

To facilitate the transition between old and new training technologies, several basic research projects have been examined with regard to how novices and experts approach problem solving, decision making, and trouble-shooting mechanized systems (Halff, Hollan & Hutchins 1986). In these cases, instructional design was considered a complex problem solving activity directed toward an equivocal problem (Duchastel 1990, Rowland 1992). The purpose of modeling instructional design in this context is to determine what cognitive sources of difficulty affect the instructional designer or multimedia developer when the requirements for using an interface to computer-based tools are superimposed on the demands of the instructional design process. Studies have revealed that a large, organized body of domain knowledge is a prerequisite to expertise (Bedard & Chi 1992, Larkin 1979). In general, experts tend to perform quickly, strategically, and automatically, and base the organization of their knowledge on meaning. Experts tend to work in iterative, knowledge building cycles. On the other hand, novices work slowly and base their organization of knowledge on the surface features of the information presented (Anderson 1985, Steptich 1991).

The complex problem solving process used by experts involved in instructional design must be coordinated with knowledge about specific subject matter and current technology. For example, little is known about the cognitive demands placed on the multimedia developer. If the Air Force or for that matter, any user intends to successfully use multimedia technologies for instruction, the technology must be fully understood (Kearsley 1991). The primary objective of this research was to investigate the multimedia development process in order to extract general procedures, principles, and techniques which will assist novices to develop CBT either in the form of guidelines or when incorporated into automated tools.

One method used to investigate multimedia development was cognitive task analysis. Cognitive task analysis uses a combination of structured interviews and *thinking aloud* verbal reports to investigate both the relationships between tasks and between people demonstrating various levels of competence performing these tasks. It may reveal cognitive skills that cannot be directly observed, and of which people may not be aware. For example, instead of asking SMEs to list the kinds of problems encountered on the job and the skills required to solve them, they would be asked to formally generate and solve similar problems (Bonner 1988, Means & Gott 1988). Cognitive data, emphasizing internal, cognitive structures and processes, can contribute to traditional task analysis by providing added levels of details to derive learning objectives and assessment measures for cognitively based tasks such as prioritizing, evaluating, and decision making (Schlager, Means & Roth 1990).

Multimedia Development Research

Multimedia has been used for more than 30 years in libraries and audio visual departments of schools, government, and industry. However, since 1987, with the advent of digital video technology, the term *multimedia* has been used to mean the integration of all media-- text still images, graphics, audio, and full motion video. More recently, the term's definition has been ambiguous; multimedia has been used more as a marketing term to cover a broad range of products which provide little more than pictures with text. For this project, multimedia is defined as the integration of all media in a digital environment for interactive use. The process of creating applications which integrate these elements is the multimedia development process.

As DVI and other multimedia technologies become increasingly supported by software tools, more references are available regarding equipment, technological processes, technical, and creative roles (Burger 1993, Bunzel and Morris 1992, Luther 1991). These three texts offer comprehensive presentations on DVI technology, software, hardware, authoring systems, and special effects. Ripley (1990) also effectively summarizes the challenges of working with digital presentation technologies. A technical paper by Gavora (1991) focuses on how learning behaviors and instructional systems are affected by digital multimedia delivery. However, few observational studies have documented the complex multimedia development process. One study by Hribar et al. (1992) describes unique considerations for using DVI to develop a submarine training system, including assembling a multimedia development team. Other research issues defined were: 1) importance of understanding the technology; 2) still image resolution, size, and format; 3) original image source; 4) use of video, and; 5) authoring language.

II. METHODS

Observational Data

The observational component of this study focused on accomplishing three goals: 1) providing a preliminary description of the competencies required of an expert multimedia developer; 2) documenting multimedia development and production and; 3) producing an

empirically testable model of multimedia development. Observational methods, such as task analysis, and structured interviews, used to obtain a large amount of qualitative data, were appropriate during this initial stage of research to define the kinds of knowledge, skills, abilities, and relevant background experience used by an expert multimedia developer. In addition, these same methods were also effective at analyzing the working relationships between development team members (e.g., instructional developers, programmers and SMEs), as well as the type, organization, and sequence of activities required to produce multimedia courseware.

A research analyst was dedicated to observing the participants involved in multimedia development during most scheduled activities, ranging from preliminary team meetings and tape mastering sessions, to a final demonstration of the prototype lessons. Informal activities and interactions were also observed during several technical discussions and programming sessions. Most sessions were audio taped and supplemented by extensive written notes. Details were confirmed or modified, if necessary, during regularly scheduled meetings with the multimedia development expert using direct questioning. Problems were clarified and additional information was elicited. Behavioral samples were obtained to identify skills and abilities used by team members, how they interacted with each other, and how, generally, behaviors changed through time. All versions of paper documents produced during multimedia development, such as storyboards, milestone charts, narration scripts, etc. were dated and catalogued.

During the early weeks of the research project, the observer conducted a warm-up session for verbal reports. The purpose was to introduce everyone to the formal knowledge elicitation process, and to help them feel comfortable *thinking aloud* in both current and retrospective modes. The observer picked two problems from Ericsson and Simon's (1984) *Protocol Analysis*: one involved verbally solving a complex multiplication problem; the other involved verbalizing the process of thinking about his parents' house and counting the number of windows. After these sessions the observer gave feedback about the responses. Feedback contained guidance about the thinking aloud process rather than qualitative judgments. This brief warm-up session served to establish the ground rules for future debriefings.

All scheduled meetings were audio taped. With the exception of two trial transcriptions during the early part of the process, these audio tapes were not re-played or transcribed due to the effort which would be necessary to code and analyze the transcription. They were available, however, in case questions arose about events. Occasionally, the multimedia development team worked when no observer was available. In these cases, the observer obtained data during debriefing of participants, and also collected written notes or other materials pertaining to the status of lesson development.

Knowledge Elicitation

Knowledge elicitation methods are techniques for knowledge acquisition dealing specifically with the collection and analysis of material obtained during direct interaction with a subject matter expert and producing a model of that knowledge (Pidgeon, N. F., Turner, B. A., & Blockley, D. I., (1991). A well-known example of a formal knowledge elicitation method and cognitive process coding scheme is protocol analysis using verbal data (Ericsson, K. A., &

Simon, H. A., (1984). Verbal data are derived directly from observations which then must be clearly and objectively coded based on previously defined criteria. Data can be recorded for transcription and coding. If only general impressions are required, an observer can complete simple checklists, or maintain a narrative record of events and activities. However, transcripts are useful for making the encoding process more explicit and objective since they ensure that all, rather than select data are recorded. Observers who code behaviors as they occur, without reference documentation, may eventually make subjective judgments or end up with an incomplete record.

Knowledge elicitation is an extremely complicated and labor intensive process because it is often difficult for an expert to describe knowledge which has become tacit, intuitive, and hard to communicate about. Cooke's (1992) taxonomy and evaluation of knowledge elicitation techniques is an excellent review of the literature in this area. She classifies "direct methods," as techniques involving direct reporting of verbalizable knowledge, such as interviews, questionnaires, simple observations, and think aloud protocols. Unfortunately, many techniques lack face validity and are unable to combine representations of knowledge from multiple experts (Cooke 1992).

Informal methods of observation were very useful for the current research project. Initially, they promoted rapport between the observer, the multimedia expert and other development team members, and helped to define the domain of knowledge itself (Ford & Wood 1992). At the beginning of the project, use of these techniques did not require an observer conversant in multimedia. However, both multimedia and instructional design expertise were required in converting the raw data into a comprehensive model of multimedia development.

Critical Incident Technique

The critical incident (CI) technique (Flanagan 1954), which distinguishes between effective and ineffective goal directed behaviors, was used as a framework to organize much of the data. The approach provided useful information about reasons for problems, common errors, and alternative strategies. The technique utilizes a set of procedures for collecting and ranking important facts (based on observations), and organizes them into a series of relationships that can be tested by further observations in more controlled studies. The CI technique uses rules which strengthen objectivity and enhance reliability. This includes basing research goals on a general aim, along with simple non-interpretative judgments performed only by qualified observers (Flanagan 1954).

Analysis of CIs can also be supplemented by cognitive process coding schemes, also called protocol analysis, verbal reports, or verbal analysis (Hamm 1987; Lusk, Smith, and Neal 1988) as well as by structured interviews and administration of questionnaires. The goal of these kinds of methods is to evaluate the subject's cognitive processes by verbal methods (Ericsson and Simon 1984). Verbal data are derived directly from observations which then must be clearly and objectively coded based on previously defined criteria. Evaluation of cognitive processes in the context of task analysis is most appropriate for developing or testing models of cognition. While this research project initially planned to conduct protocol analysis on selected transcripts on an

experimental basis, the process of transcription and coding proved too complex and time consuming to justify for this preliminary research effort.

Documentation of Processes

Job and Task Analysis

Job analysis identifies the requirements and tasks associated with a particular job, whereas task analysis breaks down individual tasks into their component parts or subtasks in order to identify the behavioral implications of the task, the functions of the expert, and the relationship of the task to the job in general (McGraw & Harbison-Briggs 1989). There are no previous studies available on job or task analysis of multimedia designers with which to compare the results of the current study. One goal of job and task analysis was to define the principal roles, organization, structure, individual components, and sequential relationships between the specific duties of the multimedia developer and other development team personnel. Additional information was obtained about skills and abilities, branching points, problem solving and decision steps, communication between development team members, perceived relative importance of tasks, and perceived need for specialized background training (Meister 1985). Data were also obtained about required specialized equipment, tools, materials, and environmental setting. Data pertaining to multimedia development were categorized into five major phases (roughly analogous to Instructional Systems Development [ISD]): analysis, design, development/production, authoring, and testing. In particular, production encompasses many activities unique to multimedia development in general and DVI specifically, compared with similar interactive courseware development projects.

Several roles can be identified on the multimedia development team. While each of these may require unique adaptations of individual tasks, in general, each role is similar or identical to those on traditional courseware development teams. The uniqueness of multimedia comes from the incorporation of video elements into the courseware development process. In the following sections the various roles of the multimedia development team are described. In general, depending upon the size and complexity of the project, these roles can be filled by a single individual, several individuals or one individual may fill more than one role. In any event, these functions are ones that normally must be performed. To the extent that the multimedia development team possesses the education and experience combination necessary to perform all functions successfully, the team and the interactive courseware produced will be successful.

Project Manager. The project manager or project administrator normally organizes the project and the team and may also have day-to-day project management responsibilities. In order to properly perform project planning, the project manager must be aware of all aspects of multimedia development, how long various processes take, and who is qualified to work on what tasks. Communication skills are essential for coordinating client needs, managing subcontractors, negotiating with vendors, controlling expenses, and allowing for the expression of creative concepts among team members within project constraints. The project manager should monitor technology and project production schedules. Checks should be put in place to ensure the timely completion of storyboards, shot sheets, flowcharts, and other multimedia

products so that the application meets the needs of the client. The project manager is ultimately responsible for the quality of the interactive courseware product, therefore, he should put those quality control measures into effect which are most effective for the team and the project.

Analyst/Knowledge Engineer. The project analyst or knowledge engineer's job is to articulate on paper the content of the application so that other team members can develop and build on the application. Content originates from observing and/or interviewing SMEs, researching technical publications, manuals, existing training materials, videos, or any other available sources which accurately describe the job. It is useful to have the ability to extrapolate knowledge from observations, have insight into underlying covert behaviors, and to organize real world experiences into useful descriptive information. Highly refined listening and organization skills are essential.

Graphic Artist. The role of the graphic artist is to produce the graphic designs, templates, textures, colors, graduated backgrounds, typography, and transitions used in the interactive courseware. Relevant background should include knowledge of computer graphics, a full appreciation of the capabilities and limitations of screen dimensions and cathode ray tube (CRT) or backlight effect of colors on human interface. Interface design issues must be understood in order to create screens, buttons, or menus, as well as a familiarity with aspects of visual perception as they apply to training systems. The graphic artist needs to know about image capture, including how to scale and crop and images, how to select one image for use over another, and which parts of an image to use. Multimedia provides the software tools for image digitization, while various software packages enhance these capabilities. Ability to work with and manage large quantities of graphic data is useful since multimedia applications often use numerous images.

Instructional Designer. An instructional designer traditionally works with the SME to ensure that the training system satisfies the requirements of the client. This job requires a background in ISD and educational technology, including knowledge of information delivery and cognitive issues. The instructional designer should have experience with user interface techniques in order to define such things as lesson navigation and rules, looping sequences, escape (pause), *help*, and *more information* support. Ideally, additional knowledge should include the status of emerging technologies, expert systems, intelligent tutoring systems, hypermedia, and multimedia. The instructional designer should also be familiar with programming, authoring, and the structured design of software for training applications.

Programmer. The Programmer should understand the courseware development process and other issues associated with designing, programming, and testing courseware. The programmer should also know multimedia technology (hardware and software), and the programming language to be utilized (in this case C or C++); if using an authoring environment (or higher level programming language), proficiency with the authoring language is important. The programmer should be able to work with the team to interpret storyboards, flowcharts, and scripts which will be used to link the multimedia elements. Programming or authoring a multimedia application becomes an intensely exciting activity when it is time to integrate all the multimedia elements into the final product.

Technician. A computer/hardware technician is an important member of the team. This individual coordinates acquisition, installation and setup of equipment, upgrades, system modifications, compatibility problems, networking configuration, and maintenance. The computer/hardware technician needs to have a basic knowledge of existing hardware and software plus experience in working with computers, peripherals, and audio and video interconnects. Although this appears to be a relatively minor role at first glance, the computer/hardware technician is involved throughout the multimedia development process in nearly all activities.

Production Specialists. The complete multimedia development team includes a variety of production specialty roles. Traditional roles are: *video producer*, responsible for coordinating talent and equipment requirements for video production. This individual should have some multimedia and directing experience in addition to the ability to plan, manage, and supervise video production. The *photographer* integrates design and content requirements, and takes care of lighting and close-up photography. Again, it cannot be emphasized enough that these roles cannot be adequately filled by the typical man-on-the-street, or Air Force developer. As an example of how complex video production is, consider the lighting requirements for a scene. Whether to use a single light source, a two-point setup with key light and back light, or a classic three-point setup using fill light is not the kind of decision that the typical Air Force developer knows how to make. Another question is what kind of lighting to use to create greater contrast and dimension and when to apply such effects. An *audio producer* works with the video producer to coordinate talent and recording equipment. Knowledge of, or experience with training programs or documentary work is desirable. The *sound effects/music coordinator* finds and records the appropriate music and sound effects for the application. Specific knowledge of and experience working with copyrighted material is highly desirable. All production specialists should be able to communicate well among the team and with the customer.

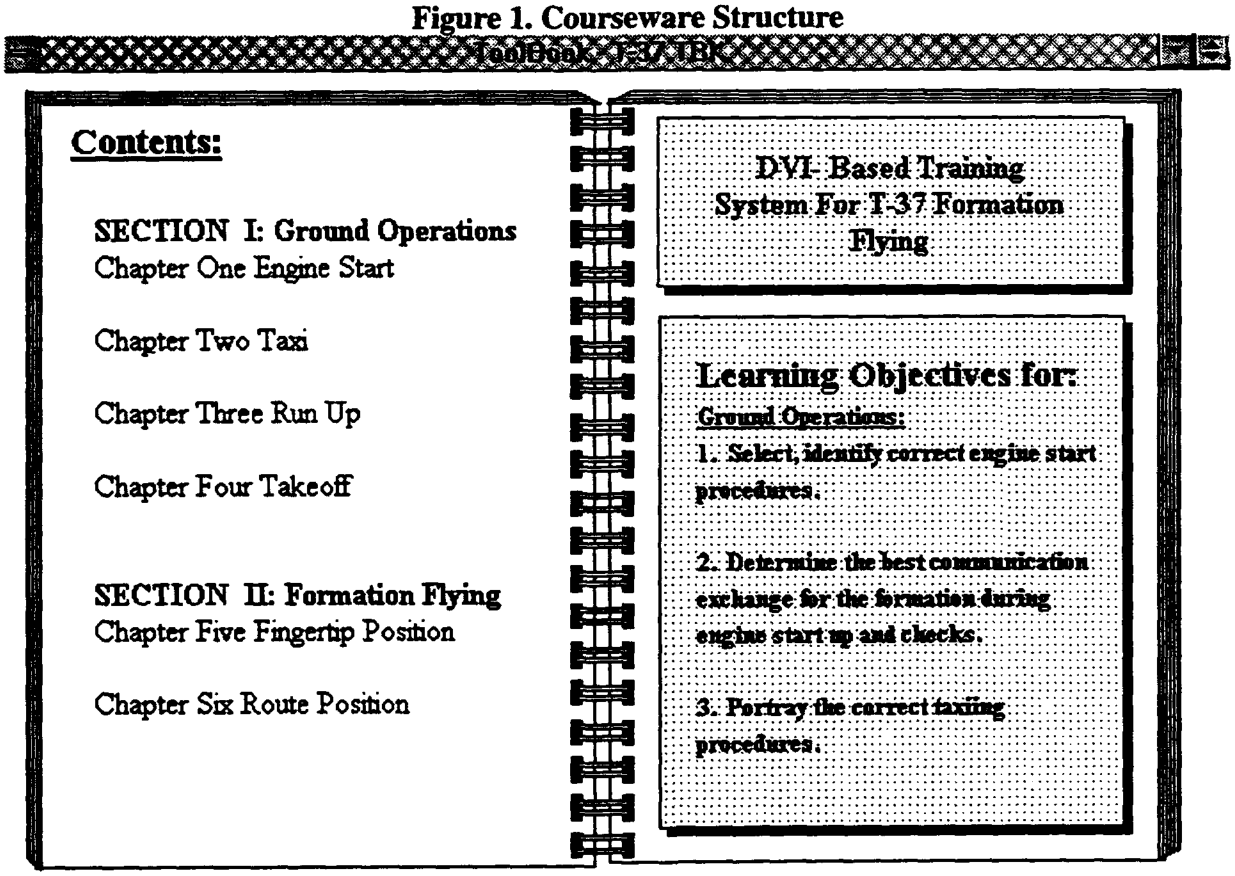
Subject Matter Expert. The subject matter expert (SME) for the T-37 formation flying lessons was from Air Training Command's 338th Operations Training Squadron at Randolph AFB. He provided help in several areas in addition to providing flying expertise. The SME was also experienced in instructional design and had a doctorate in adult and vocation education, not typical experience or education for a SME. Initially, the SME helped define topics, such as learning the proper system of visual references for formation flying which would provide an opportunity to exploit the visual effects of multimedia technology. He also suggested possible lessons that had highly visual aspects and an established base of video footage which could be used without shooting additional sequences. Close interaction between the multimedia developer and the SME elicited a wide variety of useful examples, generalizations, task variations and deviations. In addition to personal training and flying anecdotal information to make the courseware more concrete and realistic to users, the SME also provided information on learner characteristics including a description of their skills and knowledges. Some discussion centered around what the learner would already know at this point in pilot training. These decisions were important to learner control decisions in instructional design, as well as general lesson pacing.

Interactions between the multimedia developer (a composite job consisting of several skills described above) and SME were structured differently according to the stage of lesson development. Early in the project discussions were deliberately unstructured (e.g., brainstorming); at other times, the SME was given specific written assignments which produced highly structured feedback. Several knowledge engineering sessions were conducted with the SME explaining a topic to the team. These demonstrations and explanations were captured on videotape and portions were later creatively incorporated into the lesson. At other times the SME brought in other SMEs who were expert in specific areas to provide their input.

Instructional Design

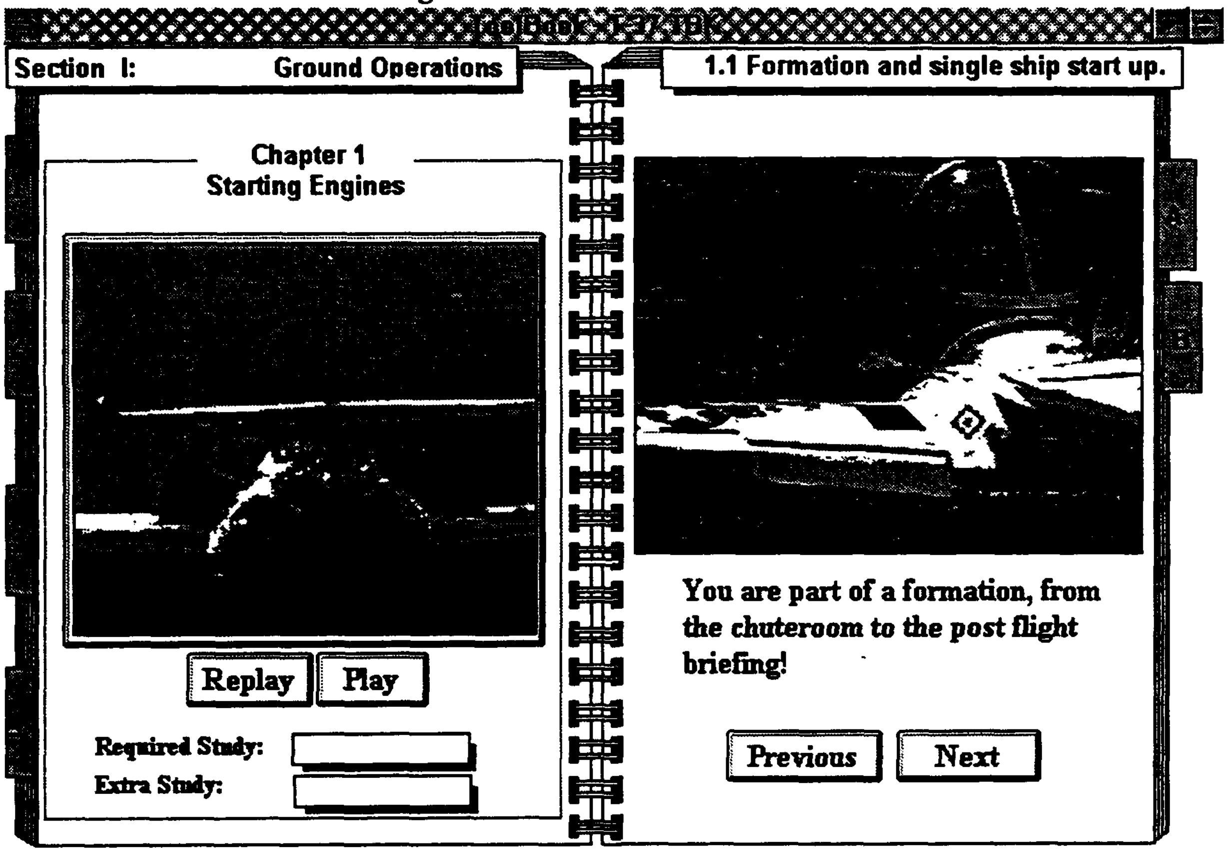
The instructional design of the training system consists of two aspects -- content and format. The content of the T-37 Formation Flying training system consisted of five modules or books. These were: ground preparations, taxi, take-off, formation flying, and landing procedures. The format of the lesson modules consisted of basic instructional pages, supplemental [illegible]al or tab pages, supplemental information accessed via hotwords, and tests. When combined [illegible] two aspects (content and format) formed the top level design of the courseware. Instructional strategies for individual lessons were selected and implemented within this overall training system structure.

Figure 1. Courseware Structure



The lesson template represents the training system's structure used to organize the presentation elements for each learning objective. A hierarchy was established for each learning objective's procedural and conceptual knowledge. Ideas and concepts often overlapped in different sections of the outline. For example, the underlying information is the same in Section I as in Section I.A.1, however the emphasis of instruction and information delivery is different (see Figures 1 and 3). Specifically, required information in the application was presented to the user, and, although the user was not required to view the supplemental information contained on a tab page, variations of required data were available. As a further contrast, this information was presented by a female voice compared to the male voice which the user normally heard in the required information pages.

Figure 2. Intuitive User Interface

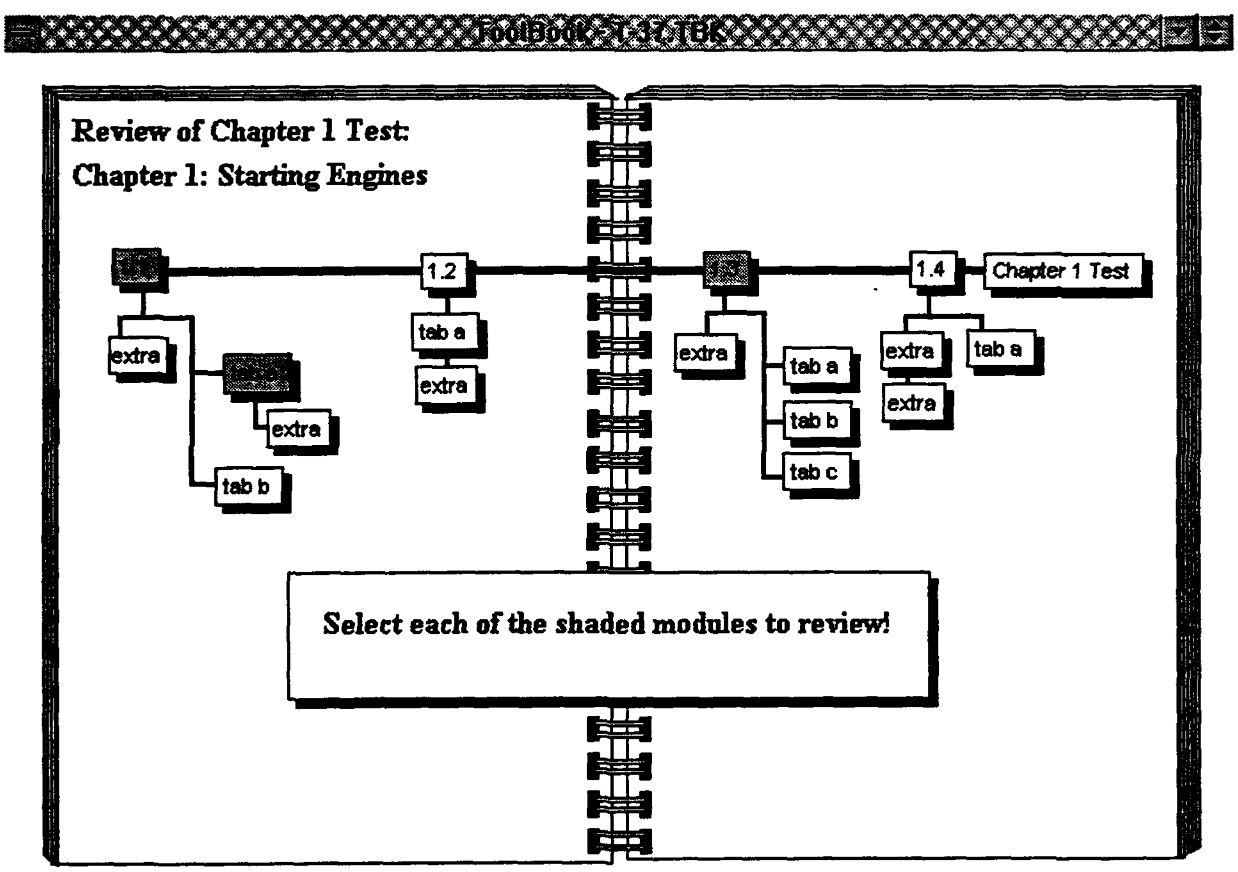


The intuitive user interface resembles a book which was based on the *Pilot's Abbreviated Flight Crew Checklist*, T.O. 1T-37B-1CL-1, (see Figure 2). Within the book, information was organized into sections and chapters. Video and audio clips were used to present the information on each page. Text, graphics, and animation were used to support and review the video. Tabbed pages, which resembled the emergency procedure section of the flight crew check list, provided supplemental information. The presentation of lesson information was intended to be similar to a documentary or pre-flight lecture. Interactive support was available on each page and in the assessment or testing modules. Testing and assessment modules were designed for meaningful

interaction and specifically supported procedural or conceptual learning objectives. For example, various animated *exercise time* figures are used to motivate students to test their knowledge by showing the proper sequence for taxiing, etc. In this type of assessment students highlight and place video images of the T-37 jet in the correct order, receive feedback, and proceed on to the next question. In addition, extensive audio narration was incorporated into each learning module. In fact, the audio narration leads the student through the mainline sequence of the lesson and also in the supplemental information. The only places narration was not used extensively was for help, hotwords and in assessment or testing.

The following diagram (Figure 3) represents the hierarchy of information delivery for each learning objective. Each box represents a simplified view of the training system's screen and available branching options. Relevant concepts and procedures for each learning objective are made available and presented throughout the different hierarchical levels. System navigation is available through a simple and intuitive user interface. This interface, allowing access to limited choices and screen buttons, allows users to become comfortable and proficient with system navigation quickly. An innovative student-teaching navigation requires the student to competently explain (or learn) concepts, procedures, or instructional goals prior to moving on through the system to the next group of objectives. If the explanation provided in the information page is not sufficient, the system will redirect the student by providing access to supplemental information. In effect, the student is not able to progress through the system unless there is articulated an acceptable understanding of the material.

Figure 3. Lesson Hierarchy



Multimedia Development.

Multimedia combines various media on a personal computer (PC) in a single digital format. The PC allows direct access to the digital information which describes each multimedia element in the application such as full motion video, high quality audio, high resolution video images, graphics, animation, and text, in the same all-digital format. Multimedia technology establishes the PC as a powerful training, simulation, and cost effective delivery platform. DVI technology, a product of Intel Corporation, is based on their i750 PB/DB chip set. These processors are dedicated to the compression, decompression, display, memory management, and integration of multimedia elements. They are contained in a single plug-in board supporting multimedia applications on the PC (PS/2 and Apple Macintosh). When configured with a snap-on daughter board, DVI can digitize full motion video, still images, and audio directly into the PC. Digitizing full motion video in real time on the PC is a technological breakthrough. Although the resolution is approximately VHS quality, this is a cost-effective method to obtain full motion video for most computer-based applications. Future generations of the product will certainly introduce algorithms to improve real time video capture quality.

Multimedia Task Hierarchy

It is important to emphasize that all activities involved with the T-37 formation flying multimedia interactive courseware development were performed solely for research purposes rather than as part of a full-scale courseware development effort. That is, repetitive activities which are normally performed during courseware development, were sometimes performed only once so that the process could be observed and documented. Some features of normal lessons such as extensive branching or remediation loops were demonstrated at points in the lessons yet they were not elaborated throughout all the demonstration lessons. Other deviations from normal development activities were explained to the observer as they occurred. In fact, a large portion of the multimedia development team's time was spent verbalizing and explaining the underlying cognition, decision-making processes, and other covert behaviors which occurred during the normal development process.

A job and task analysis (Merrill 1987) was performed to provide detailed information about the organization, structure, critical components, and sequential relationships between specific jobs, tasks, and duties of multimedia development. Multimedia development is similar to other kinds of courseware development. However, an additional process not likely to have been accounted for prior to multimedia applications is production. Production accounts for all issues related to audio, video, still image and their capture, e.g., analog to digital conversion. While production is a major part of multimedia development, the process of producing a multimedia training lesson involves several other components, including: 1) analysis, including needs assessment and evaluating hardware and software requirements; 2) design, including lesson specification and designing a user interface and system navigation; 3) implementation, including system prototype development; and; 4) testing and debugging the system.

Production embodies tasks and skills that have been applied for years by motion picture, television, and radio professionals. Multimedia development integrates several of these skills

with the skills of traditional instructional development. To a large extent the success of multimedia development depends on how successfully production is integrated into the traditional development process. In spite of its many new aspects, some elements of production are similar to traditional courseware development processes. For example, motion video production includes similar kinds of planning activities during design. Details on production and other multimedia development activities can be found in the task analysis and model of the multimedia development process.

III. RESULTS

Observational Study

A review of the observational methods used in this study shows that they were highly appropriate and effective given the preliminary nature of the subject matter and the ultimate goal of the task, i.e., to evaluate methods of documenting a novel training process. These informal methods produced a large quantity of information ranging from a detailed description of the multimedia development process, the technology involved, and reactions of the multimedia development team to their involvement in an observational study. A 108 page document was produced containing the raw data of the study spanning a 10-month period. These data are supplemented by a series of audio tapes from several of the discussion sessions, and two verbal transcripts from structured interviews.

Temporal and *sequential relationships* between CIs are potentially extremely useful and are shown in Appendix A. CIs are referred to and discussed individually in the lessons learned sections. While Flanagan's (1954) CI protocol was generally followed, the DVI usability study acknowledged many CIs which, rather than being discrete and obvious critical events, appeared to be components in a series of problems requiring solutions. However, each statement reflects an important event, activity, or decision point which ultimately had an effect on the multimedia development process.

Critical incidents relevant to multimedia development were extracted from the observational data and from retrospective structured interviews about decision points. Eighty-one CIs were identified, listed in temporal order, and classified according to types. Events were placed in one of two broad categories: management or technical. Management CIs reflected general behavior, problem solving and creative processes, and included subcategories of interpersonal activities, design, scheduling and organization. Technical activities focused on the development team's interaction with computer software, hardware and other multimedia development issues. These data were used to construct Appendix A similar to the CI chart of Miles & Huberman (1987), listing in temporal order those events perceived as important, influential or decisive in developing the multimedia lesson.

Appendix A lists CIs according to their reference number, date of occurrence, brief description, rationale, and effect. For example, CI No. 53 is described "(Developer) videotaped SMEs demonstration of (formation flying) training concepts." The rationale was "to obtain original and realistic instructional footage." The effect on the lesson was that it "provided

customized training system details." This CI was categorized as being generally relevant to management and design issues. Appendix A also lists each category and type of CI. For all cases, the reference date is either the actual date of occurrence or it refers to the date when the observer obtained the information about the event from the multimedia development team.

The effects of different CIs were of various magnitudes. For example, an early decision to develop DVI in the relatively new DVI/Windows environment (CI No. 2) was critical in planning lesson development activities as well as shaping production capabilities. Standardization of transitions between video clips (CI No. 52), by comparison, was limited to a barely noticeable component of the lesson. The arrangement of CIs according to date does not reveal any outstanding trends or associations. It appears, however, that fewer CIs occurred at the beginning of the research compared to the final months of the project, and occasionally, several content-related CIs occurred together. For example, the influence of a CI such as (CI No. 47) "Little or no documentation for DVI software," affected subsequent progress in many areas, e.g., CI No. 60, "Problem with CGA resolution displaying Targa image," and CI No. 71 "Bleeding around DVI window border." As an explanation for why fewer CIs occurred at the beginning of the project, we would offer the fact that some time was *wasted* waiting for the DVI software to be readied by vendors.

The 81 CIs shown in Appendix A were sorted into major categories and sub-types. There were 32 CIs generally classified as management, divided into three subcategories: interpersonal (2 CIs), design (28 CIs), and scheduling/organization (2 CIs). The 49 technical CIs were also divided into three subcategories: hardware (7 CIs), software (17 CIs), and multimedia development (25 CIs). This distribution of CI types seems to match the perceived pattern of activities related to management of design and technical tasks. A relatively large number of software related CIs, such as CI No. 61, "Problem noticed with maintaining detail when shrinking images," overlapped with multimedia development, even though they were separately classified. Some, such as CI No. 44, "Development team was unable to capture still image," contained elements of both design and technical issues depending on whether it was categorized according to its cause or effect. The most common source of overlap was in the technical category between software and multimedia development, which was the area the multimedia development team appeared to pay most attention to. In the context of background knowledge and expertise on doing multimedia in the Windows environment and availability of tools, these CIs appear to accurately reflect the nature of the most important issues affecting the multimedia development process.

Multimedia Job/Task Analysis

As part of this study we conducted a prototypical task analysis of the multimedia development process including multimedia development and video production. Part of the task analysis was a result of the observational study. After the multimedia development effort was completed, we also debriefed the multimedia development expert to elicit from him those tasks performed, the skills and knowledge required in performance of multimedia development, and indications of what elements of multimedia development are most affected by individual creativity. As a result of debriefing the multimedia expert, we asked him to develop a task listing

of the various activities involved in multimedia development. The results of this task are found in Appendix B: Multimedia Job and Task Analysis.

Appendix B contains raw data which has only been edited superficially to eliminate redundancies whenever possible and to standardize the data along the lines of traditional Air Force ISD. The numbering system used reflects that provided by the multimedia expert, and in no way relates to the numbering system used in the Multimedia Development Model found in Appendix C, although both of these appendices are loosely related. The task data serve two purposes: 1) it provides an initial look at multimedia development skills as they relate to interactive courseware development, as such it can form the foundation for additional research into the multimedia development process; 2) it formed the basis, along with the critical incidents derived from the observational study, for the development of a model of the multimedia development process as it fits into the ISD process (see Appendix C).

Ideally, both the task analysis data and the model of multimedia development should have been available throughout the study for comparison with the actual data and observations, but as this was an initial study of multimedia the analysts did not have either document to refer to. These appendices now provide a foundation for further study of the multimedia development activities. Ultimately, additional studies would result in additional detail for both tasks and model components, thereby providing an even stronger basis for extracting multimedia principles and guidelines for novices.

Lessons Learned

Development of the prototype T-37 training application using DVI technology was extremely challenging from both a hardware and software perspective, requiring a broad range of technical skills, knowledge, and problem solving ability. As this newly emerging technology becomes more affordable, rapid changes and innovations in both hardware and software are being introduced almost daily. In fact, during the 11-month period of this project, several new advances were announced and placed on the marked that are expected to significantly influence the direction of multimedia technology. The multimedia development team encountered numerous technical challenges while working on the lessons. These are briefly listed in the critical incidents (CI) chart (Appendix A) and more thoroughly discussed in this section. Technical challenges are described in terms of their specific problem(s), solutions, and proposed alternative approaches.

Equipment Selection

A critical consideration in establishing a successful multimedia training program is determining a hardware onfiguration to satisfy requirements. The multimedia development team researched two options for obtaining hardware: 1) purchase a turn-key system, or; 2) configure and build a system. The team decided to assemble their own DVI system in order to configure a faster system with greater hardware capacity for less cost (CI 17). Research on hardware components to determine their compatibility with the Action Media II boards afforded the team additional knowledge and experience. They also found that this new technology was accompanied by

virtually no documentation and little information for guidance (CI 47). Hardware purchases were meticulously investigated and compared to avoid compatibility problems. An alternative strategy was to purchase a turn-key system, such as ones offered by Avtex or Paragon. Although turn-key systems have an initial higher cost, all hardware components undergo compatibility testing and are delivered ready to use.

An incompatibility problem surfaced between the team's custom configured DVI development PC (Gateway 2000) and the Air Force's turn-key Dell DVI PC (CI 68). For example, graphic images that displayed the correct colors on the team's PC displayed differently on the Air Force equipment. Missing colors on the Air Force PC created a random pixelating effect through the image. This new problem was identified after a previous incompatibility with the Air Force machine, and was resolved by replacing the installed 16 color VGA video driver with a 256 color VGA video driver that was downloaded from the Dell Computer bulletin board. Both computers were able to support 256 colors, the maximum number of colors able to be displayed through the Action Media II board in Windows.

The team discovered a conflict between the Power On Self Test (POST) address in the Action Media II boards and the on-board Basic Input Output System (BIOS) address of the Adaptec Small Computer System Interface (SCSI) controller board. During the system boot process, initialization code from both boards were loaded to the same system memory location. These addresses were pre-set at the factory, although they often need to be re-jumpered to avoid conflicts. In this case, the address jumpers on the Adaptec board were changed to load to another address. The Interrupt ReQuest line (IRQ) settings that peripheral devices used to inform the computer of an impending action that needs to be serviced did not conflict with the other IRQs and did not change.

Display

During the initial set-up of the hardware and software, the team experienced a problem with the monitor not working correctly when displaying DVI videos on the screen (CI 76). The monitor would turn green following completion of a motion video application and the system would sometimes lock-up. The monitor being used was a new 15-inch multiscan, non interlaced analog color display which used the Flat Square screen technology. Special properties of this monitor were described to the system via a *monitor* command included in the *AUTOEXEC.BAT* file. To resolve the monitor problem, the command was removed from the file and the VGA card was allowed to determine the monitor default settings.

Asymetrics Capture Software

One prominent limitation was the Asymetrics capture software; this software proved to be inadequate to meet the requirements of DVI training system development (CI 34). Although three levels of resolution quality could be optimally selected, the best level (e.g., highest bit capture rate per second) did not produce adequate video quality from the poor quality tapes provided for the application. The digitizing process did not recognize changing sync levels, and as a result produced flickering, bleeding, and picture distortions as the team integrated captured

video from various tape sources. Additionally, there was no pause capability to selectively play and capture segments. This required the team to edit video prior to the capture process.

Currently, video can only be captured in a 160 pixel by 120 pixel resolution window; images cannot be scaled up or down and parts cannot be added or taken away. This is a limitation of the Intel video drive, although there are plans to upgrade the drive so that it can eventually support 320 x 200 resolution. Higher resolution allows for larger, crisper images.

The team encountered another problem during the video capture and digitizing process. The capture program would abort if the AVS (capture) file exceeded the 113-116 MB range. Asymetrics reported that this problem had not been encountered during the Beta testing of this software. However, after the team provided a detailed description of their capture process, Asymetrics was able to recreate the problem. Asymetric's final Beta release of the capture software corrected the aborting problem.

Color Palette

A table of color information, called a color palette, exists in Windows that defines and sets the system colors. If these colors are not identical between microcomputers or applications, the result may be a loss of colors in bitmap images when displayed on other computers. This appears to be the problem the team experienced with the Toolbook bitmap images. Images captured (digitized) on one computer displayed the graphic correctly on that computer, but when uploaded to the other DVI development computer, the graphic frequently displayed a pixelating effect.

The team also noticed that colors for bitmap images were frequently changed to a different tint on screens which contained multiple images. Additionally, the bitmap image became distorted each time the user moved to a new page of the Book. In 256 color bitmap files (for graphic images) the color palette is stored with the graphic. The color palette is used to determine and set the colors of the displayed image. If multiple images are placed on a single page in Toolbook, the color palettes must be identical, or no more than 256 colors, otherwise images may contain undesirable colors. Similar undesirable effects occur if color palettes conflict with the graphics on other pages of the Book. As the pages are displayed, conflicting palettes force a re-paint of the screen each time a different palette is used. The result is a distortion of the image and a brief delay each time a new page is displayed. The solution is to ensure the same color palette is applied to all graphic images during the creation process.

Bitmap Images

There was a common problem moving (e.g., dragging and dropping) bitmap images on the display screen with a mouse device. Frequently, residue in the form of lines or dots appeared on the screen as the image moved. The team investigated this problem and proposed some possible solutions. First, all drag and drop images were set to *drawdirect*. This eliminated the residue problem, but caused the image to noticeably flicker when it was dragged. This solution was not implemented since the flickering was more irritating than the residue. Drawdirect images flickered when they were moved because they were composed directly on the screen rather than

off-screen in memory. Second, the team refreshed the background each time the image was moved. This approach removed the residue once the movement of the image was completed. However, the residue still appeared while the image was in motion. This solution of refreshing the background also introduced unnecessary processing overhead. The team noticed that the residue problem did not exist on the Air Force DVI development computer. It appeared that the VGA driver for the team's computer caused the residue to remain on the screen. To fix this problem, the team downloaded a new VGA driver from the Diamond SpeedStar bulletin board.

Audio Level

Two weeks after building the production digital video files, the team noticed a significant drop in the level of audio volume on certain frame sequences in one of the files. This file was digitized and loaded to hard disk storage at the production studio by playing the master analog tape on the professional analog equipment and capturing (digitizing) it directly to the DVI development computer's hard disk. At first the team thought that the decline in audio may have resulted from a damaged audio track in the file. Their initial investigation showed the file to be intact with no degradation to either the audio or video. Using special DOS-based utilities for verifying the format of AVS files, the team was able to demonstrate that the file contained no abnormalities Further investigation using an analog meter to measure the audio decibels (DB) revealed that the master tape had significant intermittent drops in audio volume due to inconsistencies in the production process (CI 67). The remedy was to re-digitize the problem file and boost the audio through an audio mixer/amplifier. The same results could also have been obtained through a manual volume adjustment process using an audio compressor limiter device.

Scripting

Toolbook was the authoring environment used to develop the lessons. OpenScript was the object-oriented language used to produce the script routines to control the behavior and properties of objects within the application All applications created within Toolbook were event-driven, such as pressing the replay button or requesting the index, with events in turn triggering a message. Each message in turn is sent to an object which may or may not have an associated script programmed to respond to it.

Management Issues

The development team which worked on this project was very small. In fact, for the first several months while waiting for software issues to be resolved the multimedia developer alone worked with the SME. The multimedia development process would have been different if there had been an interactive courseware production schedule to meet with a larger development team involved from the beginning of the project. For example, the team would have had many overlapping tasks and different individuals would be working in parallel on the same task. In the case of this research, the number of personnel participating was purposely limited. The focus of the study was on multimedia development and production, and consequently the team was limited to only those necessary to contribute to the research goal.

Observational Research Issues

This preliminary study focused on observing the behavior of a multimedia expert and development team working on a small research project that may or may not be representative of all multimedia development efforts (Perez and Neiderman 1992). Detailed analyses of observations of the multimedia development processes produced data on temporal and structural relationships between tasks and personnel. Although there is a lot of variability in terms of personal experience and problem solving strategies, some proposed models of structure and process may be representative among individuals, situations, and diverse behavioral phenomena (Greene 1988). Further observational research in this area will help clarify relevant multimedia development decision making behaviors for integration into computer-based courseware authoring aids.

Two other aspects of conducting observational research should be considered. First, the presence of an observer can affect the subject's behavior as well as the interaction of team members. A short period when the observer does not collect data but allows the subject(s) to accommodate to the observer's presence is useful at the beginning of the project. It was also appropriate at this time for the observer to explain her role in the research project and to describe what was expected from participants. The observer stressed that factual data would be collected; no judgments would be made about the value or utility of behavior. There was no right or wrong multimedia development process. It was emphasized that team members were not expected to perform for the observer. The team was expected to make mistakes and the observer was expected to document exactly what the team did.

Second, it sometimes appeared to the multimedia development team that the observer asked numerous basic, and sometimes redundant questions. Without the observer, team members would not have had to stop what they were doing to answer questions. Sometimes the questions required answering with a lot of details or diagrams. This helped document the multimedia development process. The observer also frequently asked the multimedia development team to verify the observations. Whenever there was a lot of activity, different activities occurring simultaneously, or activities occurring when the observer was not present, the observer questioned the participants about what they did. This was occasionally viewed as an interruption, and extraneous to the project as the team was focused on multimedia development not research. It was helpful for the observer to learn as much as possible about multimedia development and DVI technology before the project started in order to reduce the number of background questions and focus instead on the processes unique to the T-37 formation flying interactive courseware development.

This project generated numerous data for one observer to record and organize. This endeavor would be far more complicated if the team had several more members or if the project were larger in scope. For non-pilot data, participation by two or more observers would be useful for increased validity, reliability, and effectiveness. Additionally, a full scale production project could incorporate more labor-intensive methods such as protocol analysis. If protocol analysis were used, computer programs which analyze qualitative data, including content analysis and coding, would help streamline and standardize these tasks (Richards & Richards 1991).

DVI Technology

As an enhancement to computer-based training technology, multimedia, and specifically DVI technology as a delivery platform for highly visual skills and tasks, provides many new opportunities for conveying information, including developing and delivering training (Luther 1991). These are characterized by: 1) increased storage capability for digital data; 2) ability to randomly access these data, and; 3) ability to electronically produce and edit audio and visual materials. These capabilities have important implications for facilitating teaching and learning. The incorporation of video into interactive training systems can present dynamic information to students while increasing their attention and potential involvement in the lesson. Flexible or random access to information offers increased opportunities for student interaction including branching, assessment, and feedback.

Hardware/Software Configuration

This project used a Windows-based DVI development environment. Hardware and software decisions reflected the Laboratory's goal to develop on a system compatible with potential future Air Force computer-based training platforms, including Windows-based AIDA.

Table 1. MPC Standards

CPU	386SX or compatible microprocessor
RAM	2 MB
Magnetic Storage	Floppy drive, 30 MB hard drive
Optical Storage	CD-ROM with CD-DA outputs
Audio	DAC, ADC, music synthesizer, on-board analog mixing
Video	VGA graphics adapter, VGA color monitor
Input	101 key keyboard (or equivalent), 2-button mouse
I/O	Serial port, parallel port, MIDI I/O port, joystick port

Multimedia platforms can be divided into three performance levels: one level is the minimum required for delivery; the next level is a high-powered delivery system; the third level is for multimedia development. A minimum level multimedia PC is capable of sound and graphics and is usually configured with a CD and a large hard drive. However, the performance requirements of digital video, higher fidelity images, sound, etc., have demonstrated that the Multimedia PC Council's (MPC) minimum standards for multimedia are already unrealistically limited. The MPC approved minimum standards for a DOS-compatible machine is shown in Table 1.

The hardware suite used on this project consisted of a Gateway 2000 486DX 50 Mhz with a 15-inch SVGA (NI) monitor, 1.2. GB Seagate SCSI drive, 1.2 MB 5.25-inch and 1.44 MB 3.5-inch Epson floppy drives, 64k SRAM cache, 16 MB DRAM, 16-bit Adaptec 1442 ISA disk controller, 120 MB Archive tape back up drive, Diamond Speed Star video board, Sony

amplified speakers, CD-ROM CDU-541, Action Media II delivery board (ISA) and Action Media II capture module.

Action Media II Boards

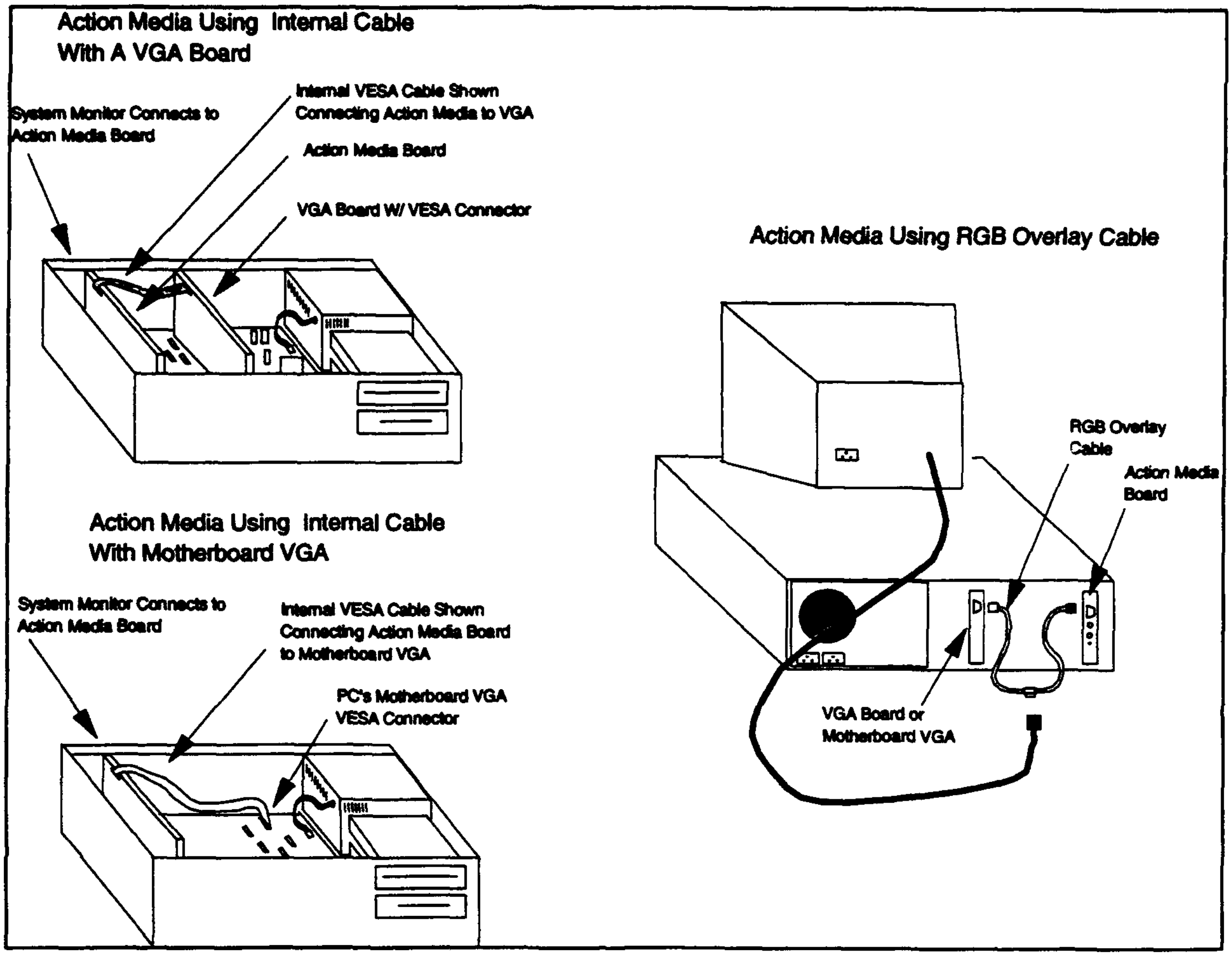
The Intel Action Media II boards are designed to provide a broad range of capabilities. The Action Media II boards integrate full motion video (full color, full screen at 30 frames per second (fps)), with high quality still images, CD quality audio, text, animation, and graphics. However, the Intel developed driver for Windows has significant limitations that severely restrict DVI development capabilities. For example, the boards are capable of producing stereo audio, but the driver restricts audio to mono only. The boards are capable of displaying or playing multiple motion video files subject to onboard VRAM constraints. Windows restricts motion video to only one active file at a time, although this limitation does not apply to still image files. Multiple still image files may be open and actively displayed as long as the onboard VRAM is not exceeded. The boards are capable of supporting 1024 by 768 by 16.8 million colors, but the driver limits resolution to 640 by 480 pixels and color display to 256.

Action Media II Hardware Configuration

The Action Media II board can be configured three different ways as shown in Figure 4. First, an external RGB overlay cable can be used which permits operation of the Action Media II board with a single video monitor. This is accomplished by connecting outputs of the Action Media II board's VGA connector and the computer's VGA connector to a single monitor. Second, connection can be made by an internal VESA cable that is included with the board. This allows for a single monitor setup by internally connecting the VESA cable between the VESA connector on the Action Media board and the VESA connection on a VGA graphics board or the VESA connection of the built in VGA of the computer's mother board. This provides the ability to mix VGA graphics with DVI video on the same monitor. The third configuration involves two VGA monitors. One monitor is used for the VGA display, including text, graphics, and operation of the authoring language; the other monitor is used only for the display of DVI video.

The configuration used influences the development of an application. For example, if an application is developed for a single monitor system, and is later played back on a two monitor system, the DVI video will be displayed in a window on the second monitor and the application will have a blank window where the video would normally be displayed. Some hardware vendors informed the multimedia development team that they could not get the single monitor external cable configuration to operate and preferred the relatively easy set up of the two monitor system. This information did not match the findings of the multimedia development team since they found no problems with their single monitor external cable system. One possible reason could be that in order for video keying to operate correctly, the authoring software must support video keying and settings within the AVK.INI files and must reflect this set up. This is usually taken care of during the installation of software and set up of the Action Media II board.

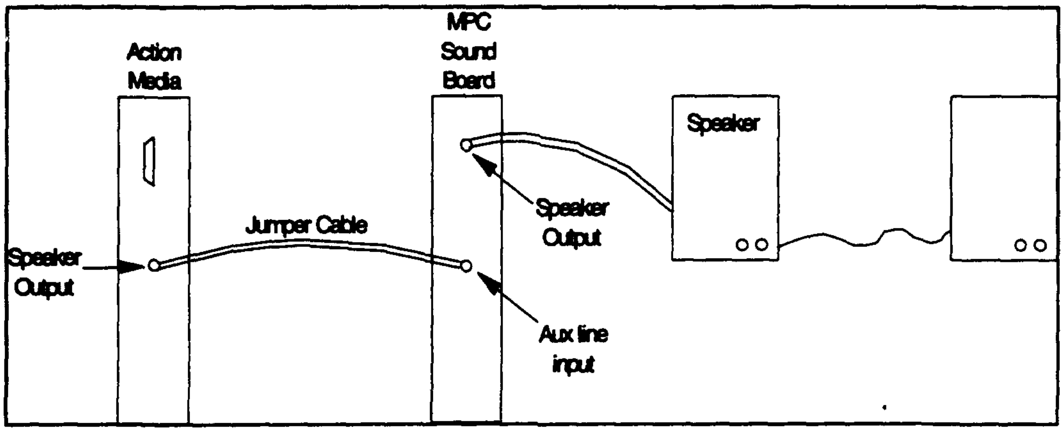
Figure 4. Action Media II Configurations



Software Options

A limited range of software is available for Action Media II DVI boards. One such package is Video for Windows. Using the Action Media II boards, this product allows the capture of audio and video at 15 fps in a 120 x 160 pixel window to a file which is called *audio video interleave* (.AVI). This format shows indications of becoming the new standard based on the availability of new software products and it is support by Microsoft. The software allows cutting and pasting of audio and video files using the standard Windows clipboard function that Windows uses for other applications such as word processing and paint programs. This is called dynamic data exchange (DDE). Currently, there are some disadvantages of Video for Windows since audio can be captured from the Action Media board but must be played back on a standard multimedia PC audio board (e.g., Sound Blaster). When an audio board is used with the Action Media board, one of two conditions must be met: 1) a second pair of self-powered speakers is used-- one pair for the Action Media board and one pair for the sound board; 2) a sound board which accommodates an auxiliary line level input on the board is used so the Action Media's audio-out can be looped through the sound board and played out the sound board's speakers.

Figure 5. Sound Board Connections



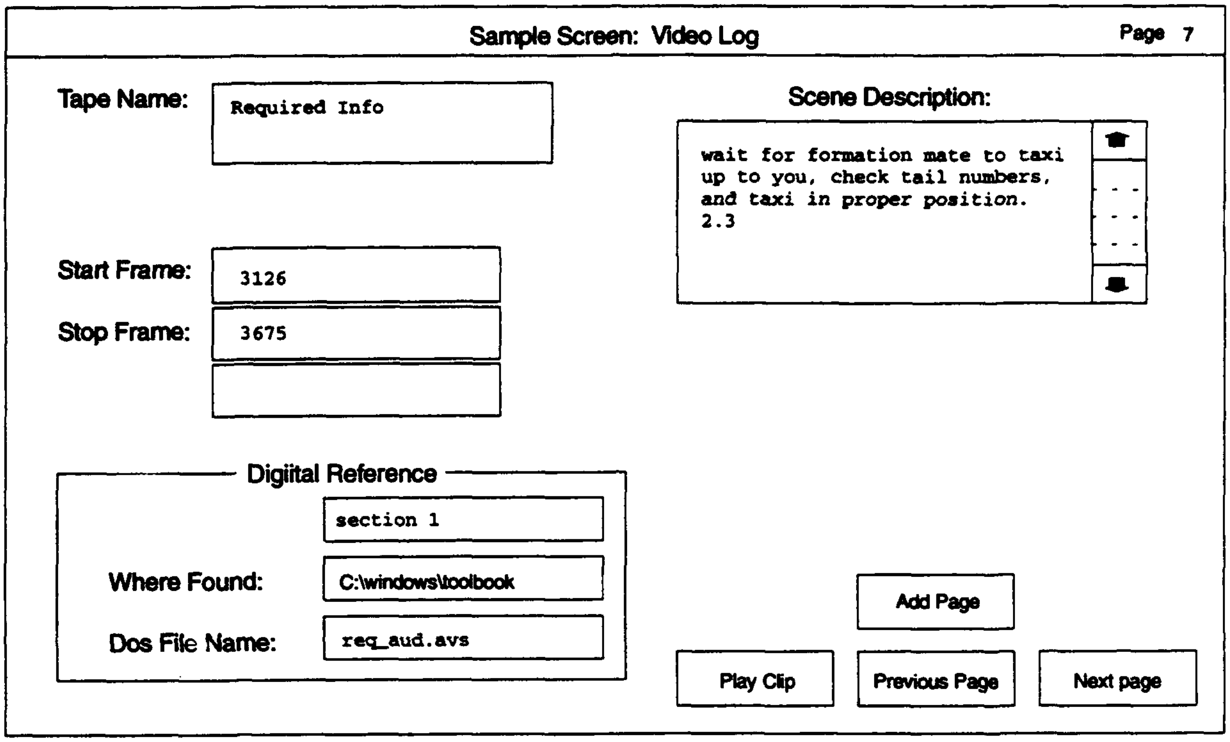
DVI Editing

There are several ways to edit audio and video for DVI. Off-line editing using production editing equipment creates a completed sequence for later digitization, which includes all the prescribed cuts, fades, transition, highlights, graphics, and text. The digitized file can then be played back in the multimedia application as a whole or segments of the file can be played (e.g., frame to frame). This process currently produces the best results since Windows-based DVI editing software is not yet widely available. However, this type of editing can be very costly if equipment must be purchased or a studio rented. Editing suite rental can range from $25.00/hour to $400.00/hour or more depending on the specific equipment and types of personnel needed. The Air Force has several editing production facilities, such as Combat Camera at Lackland AFB. Once again, a reminder that the possession of a technology does not provide the capability to use it effectively. When utilizing such facilities to develop a training program the Air Force would be wise to ensure that a sound instructional design has been accomplished first which specifies exactly what is needed. These facilities may also have access to stock video footage that may be useful in creating many multimedia applications. A word of caution about using such stock video footage in an application; if the application is produced with less than master quality or at least first generation footage, the quality of the video is reduced dramatically.

Editing can also be accomplished by digitizing clips and pieces of audio and video from video cassette recorders (VCRs), audio tape recorders (ACRs), and cameras. These segments can be cut and pasted together to create audio visual (AV) files without special effects. Such images would simply cut from screen to screen unless the captured material had existing special effects. During this multimedia development process, the only editing software available was a DOS-based editor that required a repetitive process of calculating the start and stop frames of a sequence, copying them into new files, exiting the editor, entering Windows, and playing the file to see if it appeared correctly. However, the error checking capabilities of this method were poor and could cause a system failure if frames were not correctly copied. After completing the demonstration lessons, Asymetrics released an editor utility that allows a programmer to concatenate audio and video tracks into one file, however, this utility does not permit cutting and

pasting separate audio and video tracks, other software packages must be utilized to perform these activities.

Figure 6. Audio/Video Log



Audio Video Capture Processes

Capture is the process of digitizing audio and video sequences from a source such as a VCR, ACR, camcorder, laser disk player, live camera, or microphone. Video is played from these devices at 30 fps, standard for full motion video. A frame of video contains a sampling of an instant of live video. Samples are stored in an analog format (VCRs and ACRs) or in a digital format (PC hard drives, CD-ROMS, and some high end D2 format VCRs). Several capture methods were used during this study. Asymetric's CAPTURE and PLAYER routines were primarily used for the production of the demonstration lessons. In conjunction with the capture process, the multimedia development team created a simple Toolbook application which the programmer used to log all of the stock audio and video footage (see Figure 6). This information provided the capability to search for a particular scene or event, retrieve the tape counter index number of the tape, and queue it for digital capture. Once the material was digitized, the digital reference information was entered in the Toolbook logging application for future reference. Since there was no *Pause* command on the CAPTURE routine, captured scenes may need to be concatenated together. This was accomplished through a DOS utility that was downloaded from the INTEL bulletin board service.

DVI Full Motion Video Compression

Using DVI technology to edit full motion video involves making a decision about what kind of full motion video compression to use-- Real time video (RTV) or professional level video (PLV). The capture routine software digitized each file in real time on the development system, however RTV is lower in resolution and lower in frame rate than PLV. Alternatively, in order to produce PLV, the team would have had to produce a video master and send it to a professional compression facility which uses a specialized procedure to covert to PLV. This is a relatively quick process but charges are about $250 per running minute. The multimedia development team felt that RTV produced acceptable results for their prototype lesson development (CI 57).

Instructional Design Issues

A deliberate effort was made to limit the number of prototype lesson modules (CI 14). Three learning modules were originally planned for the demonstration. One of the proposed learning modules was *rejoins*, a highly complex skill to portray. After viewing the existing Air Force videos on rejoins, the multimedia development team felt that the distant views of flying aircraft would not digitize well. Therefore, the team decided to concentrate on the modules for fingertip formation and airwork (CI 16), for a more intensive effort on fewer, but more robust modules which took better advantage of DVI's capabilities.

In a unique approach lessons were prototyped directly on the computer screen instead of going through several iterations using storyboards. The main reason for this was the fact that a single multimedia developer was working on the project, and it was more efficient to go from the ideas in his head directly to the system prototypes (CI 36). This method, however, was not particularly useful for discussions with the SME who was oriented towards the use of traditional ISD and preferred to discuss previous and current versions of the lesson by comparing storyboards.

During the entire multimedia development process the team created and maintained a comprehensive table showing the origin, destination, and status of each multimedia element, e.g., graphic, full motion video, etc. (CI 63). This facilitated programming and playback of the lesson frames and working on the lesson navigation system. Without such a database of multimedia elements there would have been confusion regarding audio, video, graphics and animation files used in the application.

The initial plan for displaying full motion video was to display graphics on the screen at certain points in the audio track, for example, an arrow comes up with a key word to show the location of visual references. However, the team discovered that this could not be accomplished during audio capture (CI 59). Instead, they overcame the problem by using the technique of specifying a frame number at which to insert a graphic overlay.

Model of Multimedia Development

One of the goals of this project was to determine what a multimedia expert does in the course of developing a multimedia application, and to extract from these activities principles or guidelines which could be used by Air Force instructional developers in working with the medium. Several steps performed during the project have provided a large amount of raw data about multimedia and the multimedia development process. In developing a model of multimedia development, we have attempted to provide some organization and logic to this data so that it can be applied to the development of principles and guidelines as mentioned earlier. The model stands alone as a representation of the *kernel activities* of multimedia development. However, it should be viewed as a first attempt at describing what multimedia development is all about. Further research is necessary to test whether this model 1) represents true generalizations about the activities of all or most multimedia experts, 2) whether it is functional in the Air Force instructional development environment, and; 3) whether all or portions of the model are capable of automation in such applications as AIDA.

The multimedia development model provided in Appendix C is a highly dynamic one in that it describes each major function or activity performed in multimedia development, and given the right input to a functional component or process it can generate or predict the output(s) of the component. The model differs from traditional surface models which only superficially represent activities, relationships or elements of a system. Surface models normally provide some graphical representation of a system and discuss in general terms the functionality of the system. This model represents a deep structure of the multimedia development process. Activities, inputs, outputs, relationships, and rules which guide the operation of the system are described to a level which provides adequate depiction of the system to allow for specific inferences to be made about how multimedia development takes place.

In modeling multimedia development activities we have couched them in terms of the greater ISD process within which they would normally fall in the course of Air Force instructional development. The top level of the model depicts the traditional ISD model. Only when *exploding* the ISD process into its individual phases do we begin to describe the impact of multimedia. Certainly, multimedia can have an impact on components of ISD other than development, e.g., it should be taken into account when selecting media, designing the training system, etc., but for this study, we focused on providing an in depth description of the multimedia development process (including production). Therefore, the model hierarchy chart indicates that data flow diagrams have only been elaborated for the major function *Develop Training* and below. According to this hierarchy chart the reader can see that the other major components of ISD to be described elsewhere.

Some explanation should be provided as to why we chose top-down structured analysis and system design techniques to model multimedia development. Several reasons can be offered: 1) one important reason is that it provides a ready set of tools for modeling systems, i.e., data flow diagrams with built-in diagramming conventions, process descriptions, and a data dictionary, 2) for modeling purposes ISD or multimedia development can be considered a *system*

with all the features of one, and; 3) any attempt to automate a system or process requires detail which most other modeling techniques do not provide.

As mentioned earlier, the derivation of principles or guidelines from this study was not the only goal. If automation is to be considered, it is first necessary to describe the system in such detail that a determination can be made as to what portions can be automated and how the automation is to be designed. This model provides readers with the ability to make some of those determinations. When viewing the model for automation, particularly in terms of being incorporated into AIDA, a system designer must bear in mind that AIDA departs from the traditional ISD approach to designing and developing courseware. Such artifacts as storyboards are bypassed by AIDA to create courseware directly. We should note that our multimedia developer also bypassed storyboarding causing some concern on the part of the SME until he became accustomed to seeing concepts translated directly into visual representations without going through the intervening paper-based steps. These factors have implications for how this model should be viewed. In other words, whenever the model indicates data are derived from a storyboard to perform some multimedia process, when considering incorporation into AIDA system designers will have to remember that those data will have to be provided by some other source.

In the strictest sense, any top-down structured analysis would describe the processes of a system with mini-specifications written in structured language ultimately aimed at automation of the system or some of its components. We have departed from that convention in this model to provide for ease of reading on the part of those oriented towards ISD rather than systems design and development. We have provided a data dictionary which lists all of the terms used in the multimedia development model.

IV. CONCLUSIONS

Behavior-Technology Interactions

Promising technologies for training are emerging in highly usable forms. Multimedia, specifically DVI, represents important new technologies because it provides an instructional designer the ability to develop and professionally edit compelling and informative interactive, multimedia lessons. Unfortunately, these are not simple tasks. Considering the highly complex processes described in the lessons learned, it is unlikely that Air Force instructional designers have the technological expertise to incorporate multimedia, specifically DVI into CBT lessons until video editing software becomes easier to use. The danger with all new technologies is that placed in unskilled hands they may do more harm than good. Without instructional design expertise and some element of creativity, tools such as multimedia can unnecessarily complicate the instructional development process, obscuring their real purpose as ways to enhance well designed instruction and make it even more effective. Further development of training aids, automated tools and expert models should facilitate the integration of technology with instructional design. Training aids for decision-making, for example, can provide more comprehensive and immediate feedback and assist users to become aware of their own limitations and biases (Wickens 1984).

The goal of expert modeling is to describe and simulate on a computer how the expert performs specialized tasks. The behavioral differences between how the expert and novice perform these tasks can be identified and steps taken to improve performance. Models can portray more than just the final outcome of a sequence of behaviors; they are capable of representing the mechanisms and means of how goals are attained (Wickens 1984). The multimedia development model provided in this report is a starting point from which even deeper behavioral models can be developed. From this model tasks, skills and knowledge requirements can be determined for each subcomponent of multimedia development activities. A more detailed task analysis can provide the basis for preparing novices to perform multimedia functions for Air Force training organizations immediately. In addition, when compared to the multimedia behavior patterns of other experts the model can be refined to depict the affinity of certain of its components to automation.

Future Use/Validation of Observational Methods

Informal methods of direct observation and interviews are highly appropriate for forming initial hypotheses for further testing. Interview data, for example, are usually complex, and relatively unstructured, but contain a wide variety of information and opportunities for follow-up study. Techniques of knowledge elicitation and cognitive task analysis are especially relevant for investigating relationships between people and machines, technology, and behavior (Howell & Cooke 1989). Future studies of multimedia development should involve observational studies of multiple teams in different development contexts for comparison and validation. Further, if two or more observers participate, protocol analysis and inter-rater studies can be used. Several other researchers have proposed coding schemes which might be an appropriate starting point for future study (Goor and Sommerfield 1975, Hamm 1987, Perez and Neiderman 1992). Feasibility studies utilizing observational data would be extremely useful for evaluating a new training system prior to implementation.

While observational methods provide abundant data for analysis when used in contexts such as this, the observational data is expensive in terms of the resources required to accumulate it. In addition, taken alone observational data cannot provide all the answers to difficult questions about technology integration into the instructional design process. Without coupling the observational data with a broader perspective of the entire Air Force instructional design context, the data tends to point to specific details which do not form patterns from which behavioral principles can be extracted.

Future Research on Multimedia

Technology is evolving in the direction of increasing complexity and interrelatedness of elements. Digital technology is becoming the standard for communication and training. Audio and video stored as data can be efficiently and widely served over networks (Pea & Gomez 1992). Computer manufacturers may eventually incorporate DVI-like applications onto motherboards of computers so that all personnel involved in training (i.e., novice instructional designers, SMEs, trainers) will have unlimited access to the technology.

The digital format of multimedia makes it a versatile tool in presenting varied applications of the same program to users depending upon pre-selected variables. For example, digital multimedia is capable of delivering instruction in multiple languages and formats simultaneously, which is becoming more important for an increasingly multi-cultural and multi-lingual population from which the Air Force selects its trainee pool (Kearsley 1991). This potential to accommodate differences in learning aptitudes and styles can provide the expert instructional designer with an additional tool to reach a broader target population.

Developments in networking and telecommunications will facilitate transmitting multimedia data. The possibility of decentralizing interactive training would also provide opportunities to offer *just-in-time* or *on demand* access to training; in this case, trainees could access lessons exactly whenever and wherever they are needed.

Potential Research Issues

The integration of multimedia into traditional ISD poses some minor questions in light of recent modifications that the Air Force is making in their approach to that process. While ISD was developed far in advance of digital multimedia technology, the ISD model is still general enough to accommodate such new technologies. Therefore, the development of principles and guidelines for multimedia should be perfectly compatible with ISD. These principles and guidelines can form the basis for training a cadre of Air Force instructional developers in the use of the technology. A reminder is in order that multimedia technology cannot replace sound instructional design. On the other hand, when the Air Force investigates the development of such technologies as AIDA which deviate fundamentally from traditional ISD approaches to instructional development, research will have to be conducted as to how newer technologies such as multimedia can be integrated into these tools. The problem does not appear to be one of compatibility, rather it appears to be finding out how this integration can best be achieved.

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APPENDIX A:
CRITICAL INCIDENTS

CRITICAL INCIDENTS

Ref. No.: 1 *Date*: 03/19/92
Category: Technical *Type*: Hardware
Description: Decided not to simulate joystick action
Rationale: Hard to replicate high fidelity training scenario
Effect: Students use mouse, focus on information presentation

Ref. No.: 2 *Date*: 03/19/92
Category: Technical *Type*: Software
Description: Decided to work within Windows environment
Rationale: Compatibility with Armstrong Lab's system
Effect: Restricted of software options and capabilities

Ref. No.: 3 *Date*: 05/21/92
Category: Technical *Type*: Multimedia
Description: Identified multi-generation/VHS quality of video (See No. 9)
Rationale: Video was at least second generation copy of original
Effect: Needed to decide if digitized image quality was acceptable

Ref. No.: 4 *Date*: 05/21/92
Category: Management *Type*: Design
Description: Decided to use modular lesson design
Rationale: Useful for programming, file management, revisions. Lesson components such as "taxiing," or "take off" were designed to be virtually stand alone. Thus making it easier to change one-out, or isolate to make revisions, or re-order.
Effect: Helpful for short-term editing and future updating

Ref. No.: 5 *Date*: 06/10/92
Category: Technical *Type*: Hardware
Description: Decided not to use CD ROM for lesson delivery
Rationale: CD ROM is static, expensive, for single prototype system
Effect: AF system would need to have a large hard drive

Ref. No.: 6 *Date*: 06/10/92
Category: Management *Type*: Design
Description: Decided not to use traditional ISD approach to instructional design
Rationale: Student characteristics, learning outcome priority, research potential
Effect: Major contribution to instructional design

Ref. No.: 7 *Date*: 06/10/92
Category: Management *Type*: Design
Description: Decision to model the multimedia lesson on effective classroom activities
Rationale: Lesson would be more interesting and effective
Effect: Multimedia used to support most objectives

Ref. No.: 8 *Date*: 06/10/92
Category: Management *Type*: Design
Description: Developer analyzed formation flying tasks and skills
Rationale: Helps communication with SME; role-plays student; effective to integrate flying jargon and potential means of student interaction
Effect: Personalized notes, explanations become part of training system

Ref. No.: 9 *Date*: 07/01/92
Category: Management *Type*: Design
Description: Decision to use parts of existing T-37 video footage
Rationale: Contained adequate information for multimedia elements
Effect: Training video would have decreased quality, fidelity

Ref. No.: 10 *Date*: 07/10/92
Category: Management *Type*: Scheduling
Description: Decided not to talk with student pilots at Laughlin AFB
Rationale: Hard to schedule; too time consuming and expensive
Effect: No new original video or direct input from student pilots needed or required for successful training implementation

Ref. No.: 11 *Date*: 07/10/92
Category: Management *Type*: Design
Description: Planned use of innovative interface techniques in system, i.e., attention loop to motivate, extensive assessment, text-based coaching and remediation.
Rationale: Increase student motivation and use of system
Effect: Added variety/opportunities to interact with lesson

Ref. No.: 12 *Date*: 07/10/92
Category: Management *Type*: Design
Description: Emphasized critical visual references students need to know to fly in formation
Rationale: Crucial concept to acquire formation flying skills
Effect: Utilize DVI to best advantage for illustrating concepts

Ref. No.: 13 *Date*: 07/10/92
Category: Management *Type*: Design
Description: Identify help and remediation elements for development
Rationale: Modularity of system could support more lesson elements in future
Effect: Potential to support embedded expert system

Ref. No.: 14 *Date*: 07/16/92
Category: Management *Type*: Design
Description: Decided to combine and limit number of lesson modules
Rationale: Developer planned to do too much originally
Effect: Modules divided into sections and separate books

Ref. No.: 15 *Date*: 07/16/92
Category: Technical *Type*: Multimedia
Description: Decided not to fly sortie to obtain new T-37 video footage
Rationale: Too expensive and time consuming to justify
Effect: Use existing 2nd+ generation video; old paint scheme

Ref. No.: 16 *Date*: 07/16/92
Category: Management *Type*: Design
Description: Decided to focus on fingertip formation and rejoins
Rationale: Most effectively shows off DVI capabilities
Effect: More intensive effort for fewer, more robust modules

Ref. No.: 17 *Date*: 08/07/92
Category: Technical *Type*: Hardware
Description: Instead of buying turnkey system, configured system
Rationale: More powerful system; lower cost; learning experience
Effect: Takes longer to get up and running; provides more versatile system

Ref. No.: 18 *Date*: 08/07/92
Category: Technical *Type*: Software
Description: Decided to purchase Toolbook instead of Authorware
Rationale: Mostly because of prohibitive cost, AF preference
Effect: Takes more time to learn how to use; harder to debug

Ref. No.: 19 *Date*: 08/07/92
Category: Management *Type*: Design
Description: Constructed learning objectives document
Rationale: ATC needs well defined statements of learning
Effect: Confirmed definitions and prioritization of objectives

Ref. No.: 20 *Date*: 08/12/92
Category: Management *Type*: Interpersonal
Description: Needed to produce separate learning objectives document
Rationale: Originally expected SME to edit other documents to produce this information
Effect: Developer adjusted his design expectations

Ref. No.: 21 *Date*: 08/20/92
Category: Management *Type*: Design
Description: SME stressed important "air discipline," in a narrow flying environment
Rationale: Training required specialization and demonstration
Effect: Focused on checklists and commands, not formulating concepts

Ref. No.: 22 *Date*: 08/21/92
Category: Management *Type*: Interpersonal
Description: Developer based discussion on unique examples or claims about topic to which SME reacted by agreeing or making substantial changes
Rationale: Helped developer find out what SME really wanted
Effect: Demonstrated that this was an effective technique for generating discussion

Ref. No.: 23 *Date*: 08/21/92
Category: Technical *Type*: Multimedia
Description: Decision to use Steve Young to narrate script
Rationale: A clear and deep voice is best for digitizing
Effect: Produced quality, "space saving" narration

Ref. No.: 24 *Date*: 08/21/92
Category: Technical *Type*: Software
Description: Realized constraints of working with Beta version
Rationale: Only cost effective and Windows software available at the time
Effect: Resulted in a slower learning curve; less versatile system

Ref. No.: 25 *Date*: 08/21/92
Category: Management *Type*: Design
Description: Multimedia developer claims potential conflict between ISD model and multimedia approach
Rationale: ISD not intended to account for all creative elements
Effect: Cannot formfit creativity into ISD model

Ref. No.: 26 *Date*: 09/04/92
Category: Management *Type*: Scheduling
Description: Unplanned delays in hardware/software availability
Rationale: Vendors unable to release products on announced schedule
Effect: Produced a delay, but allowed more time for analysis/design

Ref. No.: 27 *Date*: 09/09/92
Category: Management *Type*: Design
Description: Constructed/distributed instructor pilot survey
Rationale: Avoided travel costs; sampled more than one base
Effect: Provided data on personal experiences and expressions used during instruction

Ref. No.: 28 *Date*: 09/17/92
Category: Management *Type*: Design
Description: Developed plan to combine aspects of system/student-driven navigation
Rationale: Student must master basic knowledge to continue lesson
Effect: Innovative way of assessing information mastered

Ref. No.: 29 *Date*: 09/22/92
Category: Management *Type*: Design
Description: Used audio narration script as main knowledge piece
Rationale: Way of organizing universe of knowledge
Effect: Selected learning objectives from "universe"

Ref. No.: 30 *Date*: 09/22/92
Category: Management *Type*: Design
Description: Instructor-pilot survey was reworked and depersonalized
Rationale: Test developer made it psychometrically correct
Effect: Reworded survey de-emphasized eliciting personal expressions

Ref. No.: 31 *Date*: 10/09/92
Category: Technical *Type*: Software
Description: Created software program to lock out mouse interrupts
Rationale: Reduce confusion about system hanging up
Effect: Students not distracted by inadvertent selections

Ref. No.: 32 *Date*: 10/09/92
Category: Management *Type*: Design
Description: Specified which media accompany narration
Rationale: Developer planned to solicit support information from SME
Effect: Developer selected media to support learning strategies

Ref. No.: 33 *Date*: 10/09/92
Category: Management *Type*: Design
Description: Discussion of student vs. system-driven navigation
Rationale: Continuing debate over how student should access information
Effect: Decided on overall system directed navigation, with some student input

Ref. No.: 34 *Date*: 10/09/92
Category: Technical *Type*: Multimedia
Description: Demonstrated limitations in DVI capture routine
Rationale: Could display infinite color resolution with Targa; current display uses 256 colors
Effect: Purchased high color VGA board to improve image

Ref. No.: 35 *Date*: 10/09/92
Category: Management *Type*: Design
Description: Discussion of auditory vs. text learning
Rationale: SME emphasized text; developer wanted parallel information
Effect: Developer would produce balanced media presentations

Ref. No.: 36 *Date*: 10/09/92
Category: Management *Type*: Design
Description: Prototyped lesson on screen, instead of storyboards
Rationale: Developer working alone had ideas in his head
Effect: SME wanted to see comparisons between previous and current versions

Ref. No.: 37 *Date*: 10/29/92
Category: Management *Type*: Design
Description: SME was not enthusiastic about interface concepts
Rationale: SMEs had option to suggest creative ways of demonstrating concepts
Effect: SME expressed no visible preference at this stage of development

Ref. No.: 38 *Date*: 11/02/92
Category: Technical *Type*: Multimedia
Description: Animation was more difficult and took longer than expected
Rationale: Problem with availability of software and documentation
Effect: used restricted number of custom animation segments

Ref. No.: 39 *Date*: 11/04/92
Category: Management *Type*: Design
Description: Different narrators selected for content sections
Rationale: Helped distinguish between basic/more/test information
Effect: Consistent presentation of information to users

Ref. No.: 40 *Date*: 11/04/92
Category: Management *Type*: Design
Description: Developer "coached" narrators during audio taping
Rationale: Anticipated how audio will be used by learners
Effect: Coaching produced audio required for effective teaching

Ref. No.: 41 *Date*: 11/04/92
Category: Technical *Type*: Multimedia
Description: DB levels/subject's distance from microphone controlled
Rationale: Inconsistent volume level produced distracting audio
Effect: Developer coached narrators for correct enunciation

Ref. No.: 42 *Date*: 11/12/92
Category: Management *Type*: Design
Description: Produced audio narration "edit decision list"
Rationale: Tool was used to create template; combined multimedia elements
Effect: Used as storyboard script and "universe of knowledge"

Ref. No.: 43 *Date*: 11/12/92
Category: Technical *Type*: Software
Description: Windows DVI software lost some editing capabilities
Rationale: Beta version included only capture, playback tools
Effect: Decided to wait for software or go to production house

Ref. No.: 44 *Date*: 11/12/92
Category: Technical *Type*: Multimedia
Description: Development team was unable to capture still image
Rationale: Must retrieve and play video file each time
Effect: Took a lot of time to access files

Ref. No.: 45 *Date*: 11/16/92
Category: Technical *Type*: Multimedia
Description: Tested different data storage and retrieval formats
Rationale: Attempt to find quickest way to open and close files
Effect: Produced better coordination of multimedia elements

Ref. No.: 46 *Date*: 11/16/92
Category: Technical *Type*: Software
Description: Organized lesson elements into two big AVS files
Rationale: Avoided delay in accessing information
Effect: Eased file management; less time required to open files

Ref. No.: 47 *Date*: 11/18/92
Category: Technical *Type*: Software
Description: Little or no documentation for Windows DVI software
Rationale: Beta version lacked documentation; poor technical support
Effect: Team developed communications network to exchange product information

Ref. No.: 48 *Date*: 11/18/92
Category: Technical *Type*: Multimedia
Description: Selected post-production video and digitization
Rationale: Windows DVI editing software not yet available
Effect: Unable to develop, utilize in-house edit routines

Ref. No.: 49 *Date*: 11/18/92
Category: Technical *Type*: Multimedia
Description: Audio clips matched with video clips cannot change
Rationale: Did not have software algorithm to combine files
Effect: Unable to reuse data; lost flexibility for system

Ref. No.: 50 *Date*: 11/18/92
Category: Technical *Type*: Multimedia
Description: Constructed graphics elements list with SME input
Rationale: Time to organize and name files for production
Effect: Reviewed video footage and captured still images

Ref. No.: 51 *Date*: 11/24/92
Category: Technical *Type*: Multimedia
Description: Scripting arranged to reuse some routines
Rationale: Routines were repeated through sections of book
Effect: Reduced amount of time spent on new scripting

Ref. No.: 52 *Date*: 12/01/92
Category: Technical *Type*: Multimedia
Description: Standardized transitions between video clips
Rationale: Reduced potential distraction to learning
Effect: Limited set of transitions selected for video clips

Ref. No.: 53 *Date*: 12/01/92
Category: Management *Type*: Design
Description: Videotaped SMEs demonstrations of training concepts
Rationale: Obtained original, and real instructional footage
Effect: Provided customized training system details

Ref. No.: 54 *Date*: 12/01/92
Category: Technical *Type*: Multimedia
Description: Frame counters were different for audio and video clips
Rationale: Different frame counters were based on time/length segments
Effect: Caused significant delays in editing process

Ref. No.: 55 *Date*: 12/01/92
Category: Management *Type*: Design
Description: SMEs pointed out content inconsistency
Rationale: Used SMEs to review content integrity
Effect: Improved quality of lesson with existing material

Ref. No.: 56 *Date*: 12/01/92
Category: Management *Type*: Design
Description: Developer encouraged good video technique for SMEs
Rationale: Considered videotape as major multimedia element
Effect: Obtained good video footage of SMEs demonstrations

Ref. No.: 57 *Date*: 12/03/92
Category: Technical *Type*: Multimedia
Description: Decide to use RTV instead of PLV
Rationale: Less time consuming and expensive to produce
Effect: Images captured with limited fidelity

Ref. No.: 58 *Date*: 12/03/92
Category: Technical *Type*: Multimedia
Description: Experimented with image quality in DVI capture machine
Rationale: Different wiring might have affected image quality
Effect: Professional videotape player produced best image

Ref. No.: 59 *Date*: 12/04/92
Category: Technical *Type*: Software
Description: Could key on frame number but not audio text
Rationale: No MCI command existed for this capability
Effect: Could not overlay graphics in real time; keyed on audio

Ref. No.: 60 *Date*: 12/04/92
Category: Technical *Type*: Design
Description: Problem noticed with CGA resolution display of Targa image
Rationale: There was not enough room for information to display high quality image
Effect: Compatible driver purchased to display full screen images

Ref. No.: 61 *Date*: 12/04/92
Category: Technical *Type*: Design
Description: Problem noticed with maintaining detail when shrinking images
Rationale: Data loss was relative to the amount image was scaled down
Effect: Used visual judgment to scale images

Ref. No.: 62 *Date*: 12/07/92
Category: Technical *Type*: Multimedia
Description: Audio narration required more takes than expected
Rationale: There were analog to digital conversion glitches
Effect: Process took longer and required more patience for re-takes

Ref. No.: 63 *Date*: 12/07/92
Category: Technical *Type*: Design
Description: Created table for origins and destinations of multimedia elements
Rationale: Facilitated programming of playback frames
Effect: Facilitated working on lesson navigation system

Ref. No.: 64 *Date*: 12/07/92
Category: Technical *Type*: Hardware
Description: Discussion about upgrading Targa board
Rationale: Would permit greater variety of special effects
Effect: Decided against upgrade because it was too expensive and of limited benefit

Ref. No.: 65 *Date*: 12/07/92
Category: Technical *Type*: Multimedia
Description: Maintained only one version of audio clip on tape
Rationale: Reduced possibility of digitizing or capturing wrong file
Effect: Produced one correct version of audio tape narration

Ref. No.: 66 *Date*: 12/09/92
Category: Technical *Type*: Software
Description: Network installed to link the two DVI development computers together
Rationale: Facilitated dumping files and sharing software
Effect: Allowed developers to work on files simultaneously

Ref. No.: 67 *Date*: 12/09/92
Category: Technical *Type*: Multimedia
Description: Noted significant deviations in digitized audio file
Rationale: Inconsistent audio level noted during mastering and production
Effect: Required manually redigitizing master

Ref. No.: 68 *Date*: 12/11/92
Category: Technical *Type*: Hardware
Description: New AF DVI development system did not work correctly
Rationale: System vendor did not correctly configure system
Effect: AF system not compatible with development team's computer

Ref. No.: 69 *Date*: 12/11/92
Category: Technical *Type*: Software
Description: Found that Toolbook can handle FLC files
Rationale: Could not animate very well in Toolbook
Effect: Discovered tool for implementing animated graphics

Ref. No.: 70 *Date*: 12/11/92
Category: Technical *Type*: Multimedia
Description: Decided how to record music for training system
Rationale: Alternatives were to use DVI or MIDI with multiple tracks (non DVI)
Effect: Digitized live audio with AMII (required no specific boards)

Ref. No.: 71 *Date*: 12/19/92
Category: Technical *Type*: Multimedia
Description: Bleeding noticed around margins of DVI window border
Rationale: Initially used poor quality video equipment
Effect: Overlaid border with margin of video lines

Ref. No.: 72 *Date*: 12/22/92
Category: Technical *Type*: Multimedia
Description: Development team used point-to-point editing
Rationale: Used old editing software with new DVI boards
Effect: This was an exceptionally time consuming way of editing

Ref. No.: 73 *Date*: 01/04/93
Category: Technical *Type*: Hardware
Description: Mei's and AF's system/monitor cabling configurations were different
Rationale: Converted AF's two monitor system to single monitor system
Effect: VESA connector supplied new video features

Ref. No.: 74 *Date*: 01/11/93
Category: Technical *Type*: Multimedia
Description: Established formal video log for ATC raw footage
Rationale: Needed to organize information about frame, location, time
Effect: Facilitated obtaining video files for production and editing

Ref. No.: 75 *Date*: 01/19/93
Category: Technical *Type*: Software
Description: Book does not run on AF's system
Rationale: Computer does not recognize the MCI command
Effect: To correct the problem MCI drivers were removed and reinstalled

Ref. No.: 76 *Date*: 01/19/93
Category: Technical *Type*: Software
Description: Digitized video appeared jumpy, dropping frames during capture
Rationale: VERIFY ON in AUTOEXEC.BAT file required too much time
Effect: Turning off command resolved problem

Ref. No.: 77 *Date*: 01/20/93
Category: Technical *Type*: Software
Description: After entire file plays, image no longer fades to black
Rationale: Image remained after file closed; caused time delay to correct
Effect: AVS file/30 frames black video appended to files

Ref. No.: 78 *Date*: 01/21/93
Category: Technical *Type*: Software
Description: Progress bar did not accurately show remaining part of lesson
Rationale: Repeated tracks counted towards progress in lesson
Effect: Progress bar revised to track only new information

Ref. No.: 79 *Date*: 01/21/93
Category: Technical *Type*: Software
Description: Decision made about displaying cursor and associated audio
Rationale: Cursor would indicate for student to wait; the selection was unavailable
Effect: Student sees/hears obvious cues of system's status

Ref. No.: 80 *Date*: 01/21/93
Category: Technical *Type*: Multimedia
Description: Problem noted of locating/ordering clips in different files
Rationale: Initially used prototype approach; later, used generic code
Effect: Team modified clip "look up table"

Ref. No.: 81 *Date*: 01/21/93
Category: Technical *Type*: Hardware
Description: Amplified speakers were not responding to some sounds
Rationale: Built-in power down circuit required time to receive signal
Effect: Modified speaker power down circuit

APPENDIX B:
MULTIMEDIA JOB/TASK ANALYSIS

Multimedia Job and Task Analysis

1.0 Multimedia Development

1.1 Audio
- 1.1.1 Integrate audio capabilities of hardware and software
- 1.1.2 Select audio elements
- 1.1.3 Define the learning elements
- 1.1.4 Develop scripts for each learning element
- 1.1.5 Identify common student mistakes
- 1.1.6 Define and apply alternative explanation methods
- 1.1.7 Develop script for narration
  - 1.1.7.1 Develop scripts for positive feedback, remediation, and help
  - 1.1.7.2 Develop scripts for negative feedback, remediation, and help
  - 1.1.7.3 Ensure correctness of script content, language, pronunciation
  - 1.1.7.4 Define areas of inflection, confidence and knowledge
  - 1.1.7.5 Identify where to use male and female voice talent

1.2 Sound Effects/Music
- 1.2.1 Define special areas for effects to support
- 1.2.2 Develop script for effects
- 1.2.3 Ensure correctness, appropriateness, legal copyrights, etc.
- 1.2.4 Select, and test effects in application

1.3 Graphic/Animation
- 1.3.1 Define graphic list
- 1.3.2 Work from storyboard to develop list
- 1.3.3 Use video images if possible
- 1.3.4 Determine file size, load time, etc.
- 1.3.5 Use graphics package to create and edit graphics
- 1.3.6 Define animations
- 1.3.7 Define screen designs
  - 1.3.7.1 Pay attention to consistency of appearance and operation
  - 1.3.7.2 Define color standards
  - 1.3.7.3 Ensure clarity of instructional objective

1.4 Still Image (Video, Photo)
- 1.4.1 Identify images that can be obtained via video capture
- 1.4.2 Use full motion video plan
- 1.4.3 Create a shot sheet for stills
- 1.4.4 Work stills shot sheet into full motion video shot sheet
- 1.4.5 Use proper video formats for graphics software and application compatibility
- 1.4.6 Establish still image log or image record to facilitate development

1.5 Motion Video
  1.5.1 Identify images that can be obtained via video capture
  1.5.2 Create a shot sheet for full motion

1.6 Authoring/Software
  1.6.1 Develop prototype
  1.6.2 Design system help
  1.6.3 Storyboard navigation through system
  1.6.4 Define instructional activities and goals
  1.6.5 Develop overview of course
  1.6.6 Identify lesson composition and organization
  1.6.7 Identify subordinate teaching topics
  1.6.8 Storyboard user interface
  1.6.9 Test screen designs with instructional needs

2.0 Multimedia Production

2.1 Video Production
  2.1.1 Work from shot sheet (know image and stills requirements also)
  2.1.2 Cross-check the design of the shot sheet
    2.1.2.1 Check that all conditions accounted for
    2.1.2.2 Edit the shot sheet to reflect changes
  2.1.3 Ensure shot sheet reflects time and cost concerns
  2.1.4 Determine shoot location
    2.1.4.1 Studio shoot
      2.1.4.1.1 Prepare equipment
      2.1.4.1.2 Prepare the set
      2.1.4.1.3 Check lighting
      2.1.4.1.4 Practice shot under various conditions for best results
      2.1.4.1.5 Determine if going to video or capturing
        2.1.4.1.5.1 Determine special conditions for capturing
        2.1.4.1.5.2 Determine special conditions for tape
      2.1.4.1.6 Record progress and helpful notes into video log
    2.1.4.2 Location shoot
      2.1.4.2.1 Determine transportation and its ramifications
      2.1.4.1.2 Prepare equipment
      2.1.4.1.3 Understand natural light, weather, local authorities and legal issues, Permits etc.
      2.1.4.1.4 Practice set-up and breakdown for various shots at a location
      2.1.4.1.5 Plan, practice and prepare for one-time chance at getting the right shot
      2.1.4.1.6 Determine if going to video or capturing
        2.1.4.1.6.1 Determine special conditions for capturing
        2.1.4.1.6.2 Determine special conditions for tape
      2.1.4.1.7 Record progress and helpful notes into video log
  2.1.5 Prepare, create, acquire application related materials, props, etc.
  2.1.6 Select Camera Type and Tape Stock

2.1.7 Prepare, coach, instruct etc., the talent
2.1.8 Practice run through the shoot
2.1.9 Identify and fix problems
2.1.10 Shoot the video

2.2 Still Image Production
2.2.1 Work from shot sheet
2.2.2 Cross-check the design of the shot sheet to include still image requirements obtained From camera or video
2.2.3 Check that all still images and conditions accounted for
2.2.3.1 Edit the shot sheet to reflect change
2.2.3.2 Ensure shot sheet reflects time and cost concerns
2.2.4 Determine shoot location
2.2.4.1 Studio shoot
2.2.4.1.1 Prepare equipment
2.2.4.1.2 Prepare the set
2.2.4.1.3 Check the lighting
2.2.4.1.4 Practice shot under various conditions for best results
2.2.4.1.5 Determine if going to video or capturing
2.2.4.1.5.1 Determine special conditions for capturing
2.2.4.1.5.2 Determine special conditions for tape
2.2.4.1.6 Record progress and helpful notes into video log
2.2.4.2 Location shoot
2.2.4.2.1 Determine transportation requirements and its ramifications
2.2.4.2.2 Prepare equipment
2.2.4.2.3 Understand natural light, weather, local authorities and legal issues, permits etc.
2.2.4.2.4 Practice set-up and breakdown for various shots at a location
2.2.4.2.5 Plan, practice and prepare for a one-time chance at getting the right shot
2.2.4.2.6 Determine if going to video or capturing
2.2.4.2.6.1 Determine special conditions for capturing
2.2.4.2.6.2 Determine special conditions for tape
2.2.4.2.7 Record progress and helpful notes into video/image log
2.2.5 Determine, prepare resources
2.2.5.1 Determine lighting requirements
2.2.5.2 Prepare, create, acquire application related materials, props, etc.
2.2.5.3 Select camera type and tape stock
2.2.6 Prepare, coach, instruct etc., the talent
2.2.7 Determine capturing (digitizing) requirements
2.2.8 Practice run through the shoot
2.2.9 Identify and fix problems
2.2.10 Shoot the image

2.3 Graphic

2.3.1 Ensure the design of the graphic list accounts for the application's graphics requirements
2.3.2 Create graphic elements
2.3.3 Ensure graphics software is capable of various formats
2.3.4 Create graphics (and images) in a single color palette
2.3.5 Use database and helpful notes to log the completed graphics

2.4 Animation

2.4.1 Work from storyboards, graphic lists, etc.
2.4.2 Determine type and level of fidelity of animation (3-D, stick figure, etc.)
2.4.3 Ensure the (animation) software format supports application format
2.4.4 Create animation
2.4.5 Record animation data in database use helpful notes

2.5 Audio

2.5.1 Work from storyboards, shot sheets and other development tools that define audio requirements
2.5.2 Identify recording needs
2.5.3 Prepare equipment
2.5.4 Prepare, coach, etc. talent
2.5.5 Record audio
2.5.6 Re-record if necessary
2.5.7 Use log to record audio information

2.6 Music

2.6.1 Work from storyboards, shot sheets and other development tools that define the music requirements of the application
2.6.2 Identify recording needs
2.6.3 Prepare equipment
2.6.4 Prepare, coach, etc. talent
2.6.5 Identify Royalty Requirements
2.6.6 Record music
2.6.7 Re-record music if necessary
2.6.8 Use log to record music information

2.7 Sound effects

2.7.1 Work from storyboards, shot sheets and other development tools that define sound effects requirements
2.7.2 Identify recording needs
2.7.3 Prepare equipment
2.7.4 Prepare, coach, etc. talent
2.7.5 Record effects
2.7.6 Re-record if necessary
2.7.7 Use log to record effects information

2.8 Graphic user interface
   2.8.1 Work from the storyboards, graphic lists, etc.
   2.8.2 Ensure the design of the interface supports the application's instructional requirements
   2.8.3 Create graphic elements of the interface
   2.8.4 Ensure graphics software is compatible with application (authoring) software
   2.8.5 Create graphics (and images) in a single color palette
   2.8.6 Use database and helpful notes to log the completed graphics

2.9 Edit
   2.9.1 Select element to edit
   2.9.2 Motion video edits
      2.9.2.1 Use highest quality sources
      2.9.2.2 Create edit decision list
      2.9.2.3 Use on-line (digital) or off-line (analog) editing
      2.9.2.4 Edit video
      2.9.2.5 Record into video log
   2.9.3 Still image edits
      2.9.3.1 Use highest quality sources
      2.9.3.2 Create image edit list
      2.9.3.3 Recapturing may be necessary for image editing
      2.9.3.4 Edit image
      2.9.3.5 Record into image/video log
   2.9.4 Graphic edits
   2.9.5 Animation edits
   2.9.6 Authoring/programming edits
   2.9.7 Instructional integrity edits
   2.9.8 Sound (music, audio, effects) edits
   2.9.9 Application edits
      2.9.9.1 Test application against design specifications
      2.9.9.2 Note problems and develop a corrective plan
2.9.10 Ensure edits meet customer requirements

3.0 Authoring/Programming

3.1 Organize production components
   3.1.1 Ensure each component is complete
   3.1.2 Create, redo, or add to a component

3.2 Integrate components into application
   3.2.1 Use guidelines set by interactive and software design
   3.2.2 Work off the storyboards
   3.2.3 Work off the shot sheets
   3.2.4 Work off the graphic/animation list
   3.2.5 Work off SME's suggestions
   3.2.6 Build on the prototype

3.2.7 Work with instructional designer

3.3 Use authoring system to program components into the system

3.3.1 Test and refine code

3.3.2 Document lessons learned

3.3.3 Decide if previously completed software or hardware could be cost-effectively improved by implementing the lessons learned

APPENDIX C:
MULTIMEDIA DEVELOPMENT MODEL

Multimedia Development Model

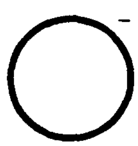
Appendix C is a model of multimedia development. The format used throughout this appendix is top-down structured analysis. This methodology consists of three separate but integrally linked components: 1) data flow diagrams (graphic depictions of the system's functions and relationships), 2) process descriptions (a specification or description of each function depicted in the data flow diagrams), and; 3) data dictionary (explanation of each term used in the data flow diagrams and process descriptions). The following is a brief outline of the methodology used throughout this appendix.

Data Flow Diagrams

These functional diagrams of the system are organized in a hierarchical fashion to provide the level of detail required by the reader to understand the system; how it works and what it does. Lower, and more detailed functional diagrams are often used by systems analysts and designers to develop detailed specifications for automated systems. The data flow diagrams depict graphically the internal processes which take place in a system, as well as the relationships that the system being described has with any other external systems. The relationship of the functions or processes which are depicted in the data flow diagrams can be shown in a hierarchy structure chart, such as the one preceding the data flow diagrams for the multimedia development model. This hierarchy structure chart shows how each function *explodes* into a more detailed description on a lower level data flow diagram. Each item listed on the hierarchy chart consists of a separate data flow diagram and associated process descriptions.

Several special symbols are used in the data flow diagrams. Each symbol has a specific meaning as follows:

Represents information or a data flow.



Represents a process or function.

Represents an information or data file.

Stands for a system external to the one described.

Process Descriptions

Each process, function or activity which is depicted in a data flow diagram has a process description associated with it. The process description describes how the process occurs, in other

words the rules governing the operation or behavior of the process. Process descriptions tell how an input or some information is used or transformed by the process, or how new information is generated by the process. Process descriptions for higher level functions may *explode* into lower level data flow diagrams which are, in turn, explained in more detail by the process descriptions of these sub-processes.

Data Dictionary

Each item depicted in the data flow diagrams or used in the process descriptions is described or defined in the data dictionary. The data dictionary is used to describe the data flows, data stores and external systems. Note that there is no data dictionary entry corresponding to a process. Processes or functions are explained fully by process descriptions.

- *Data Flow*. These are represented on the data flow diagrams by an arrow. The point of the arrow indicates the direction in which the information, report or data flows. The label is the name of the information or data.

- *Data Store*. These items are represented in the data flow diagrams by a set of parallel lines. The label is the common name for the store. The data stores represent files which are maintained by the system being described. These files can be either manual or automated.

- *External System*. These are represented in the data flow diagrams as rectangles. These are organizations, agencies, companies, etc. with which there is some functional interaction during a process, i.e., data is provided or received from them.

DATA FLOW DIAGRAMS

Multimedia Development Model Hierarchy Chart

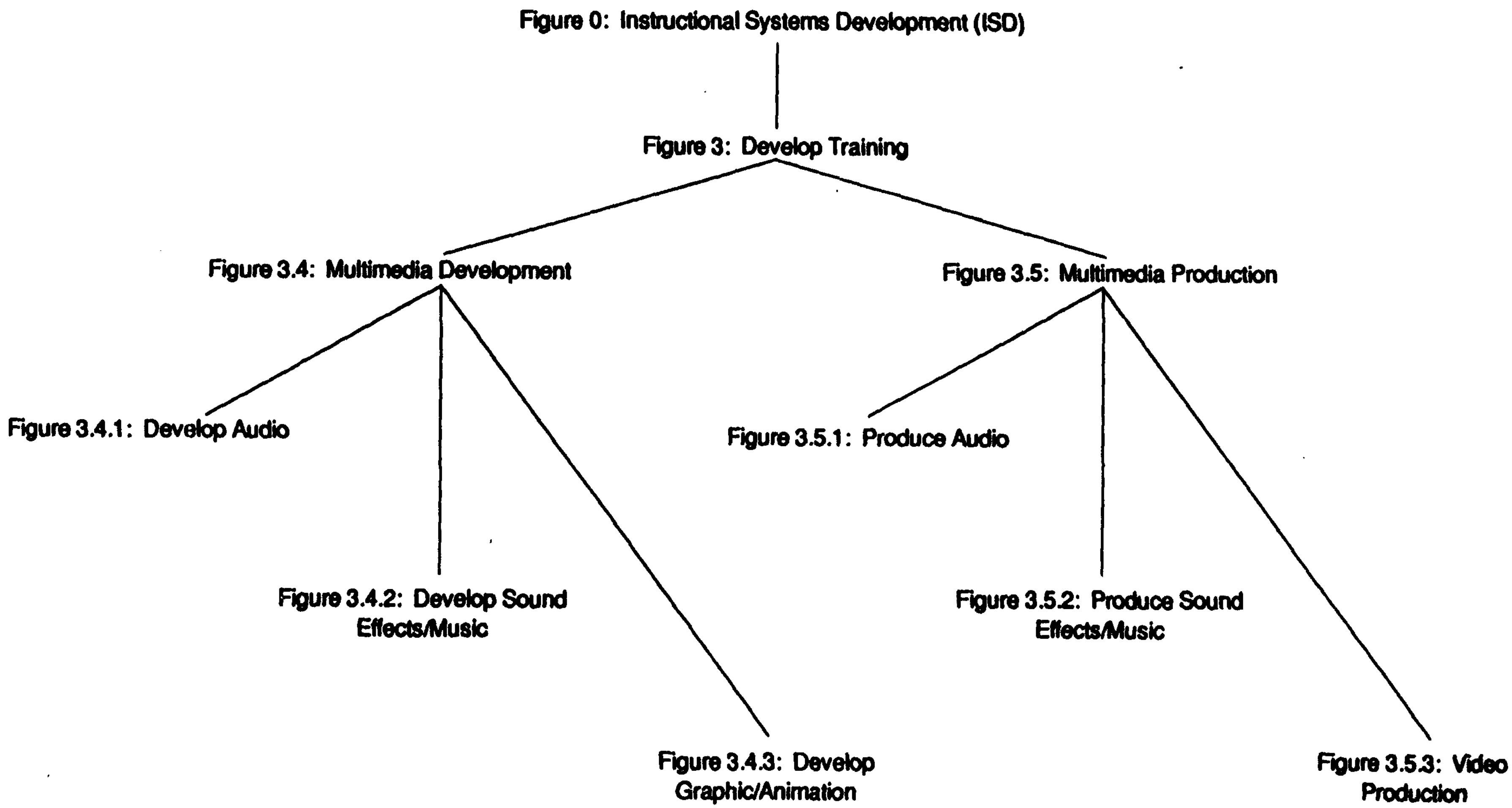


Figure 0: Instructional Systems Development

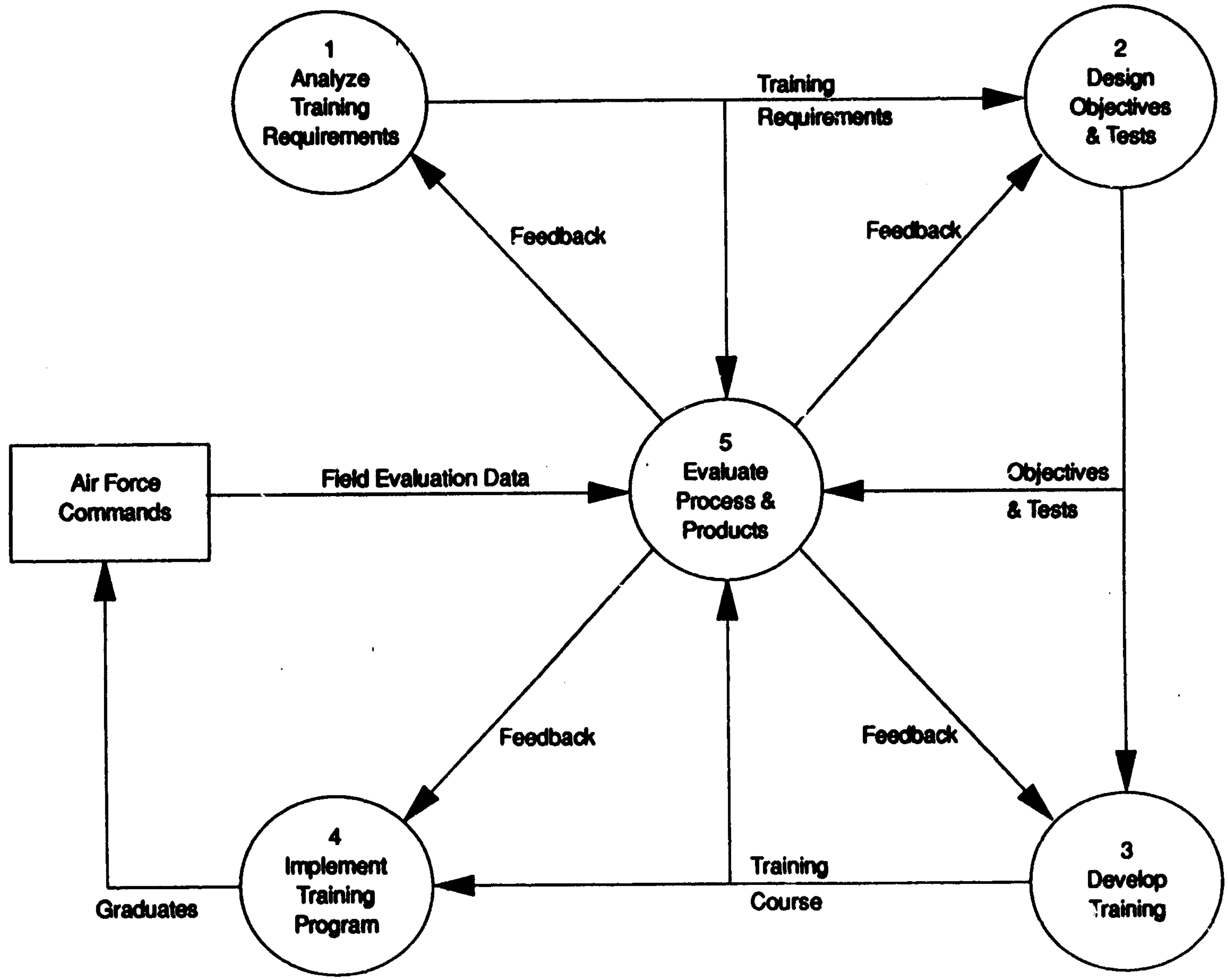


Figure 3: Develop Training

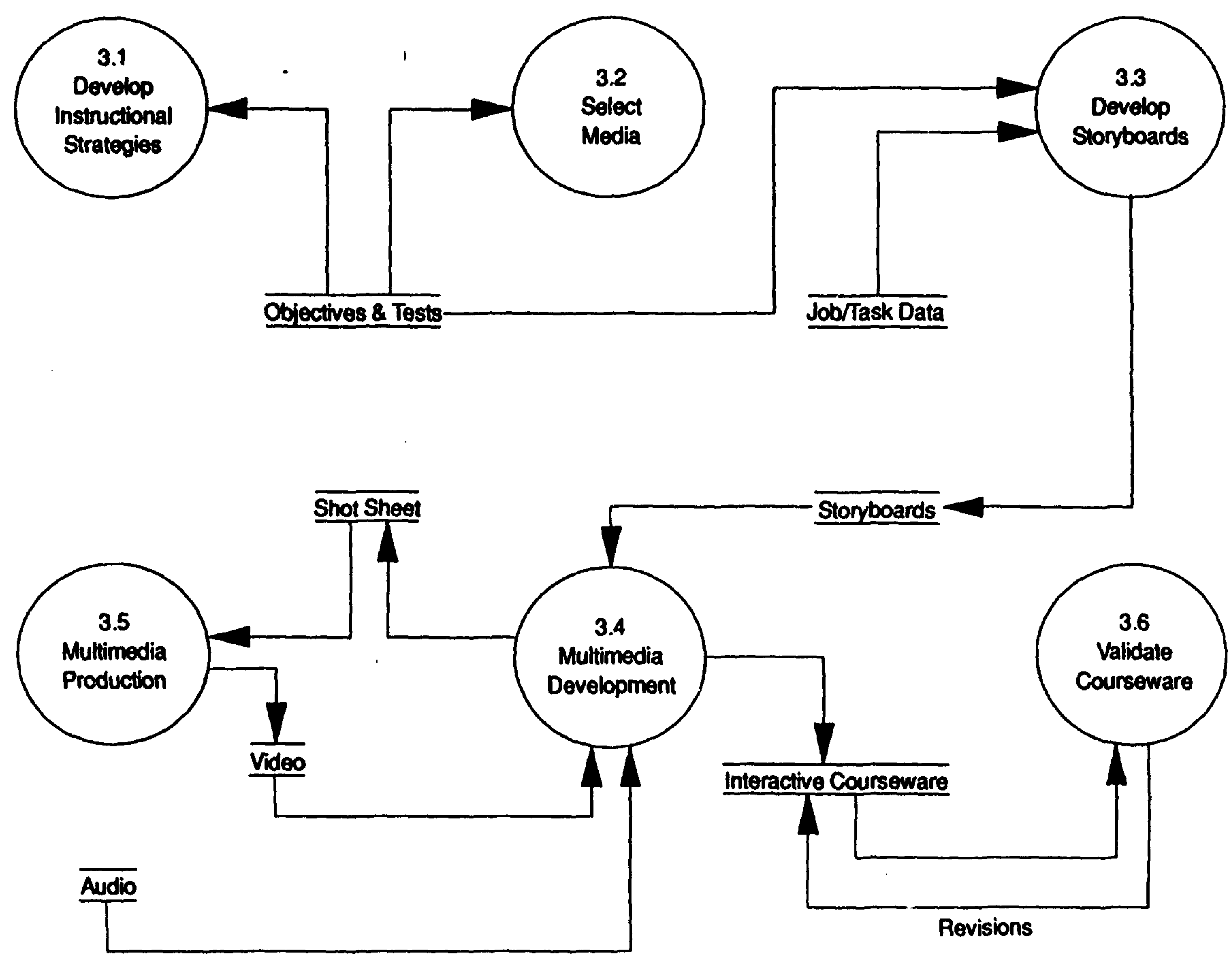


Figure 3.4: Multimedia Development

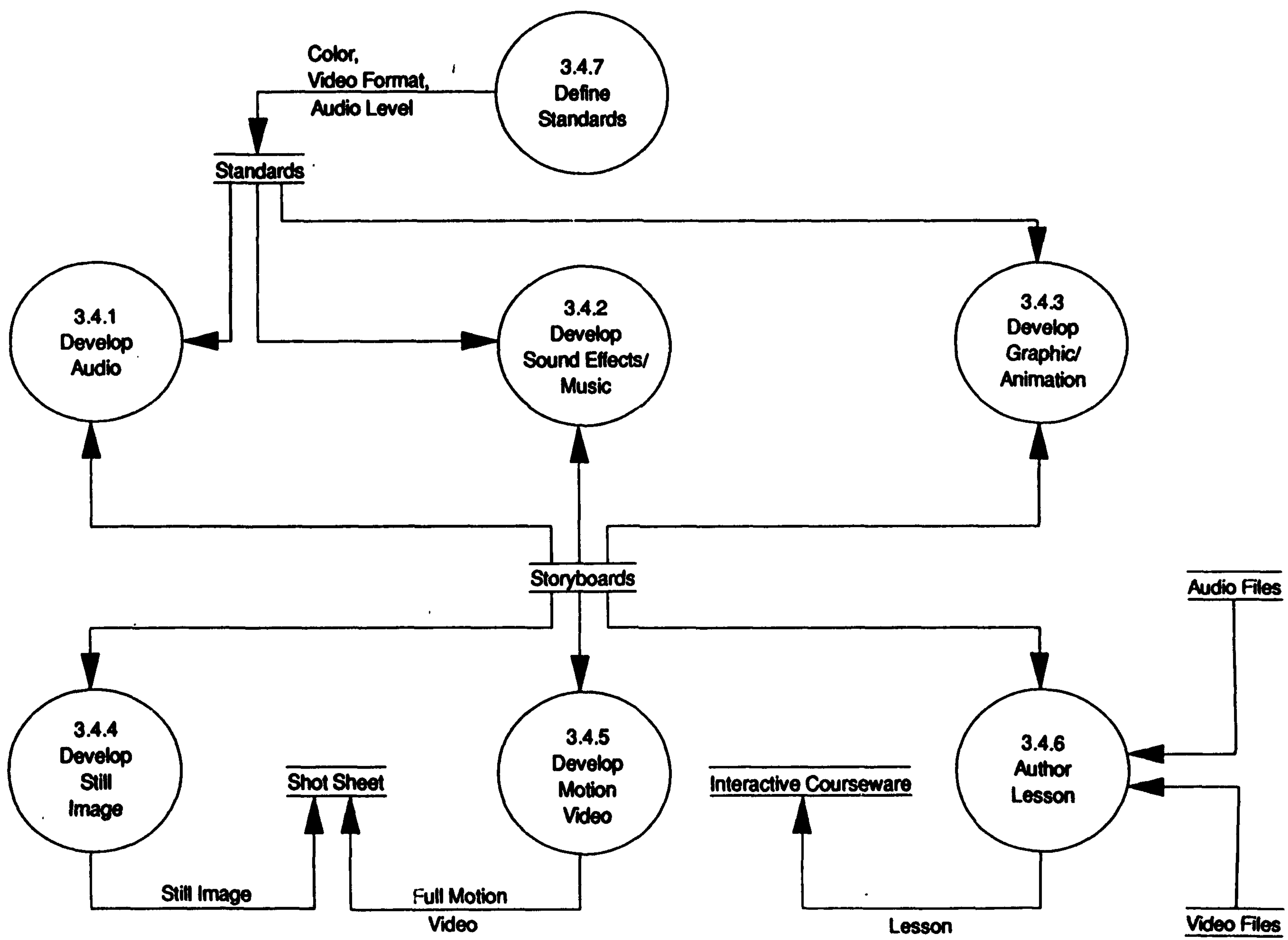


Figure 3.4.1: **Develop Audio**

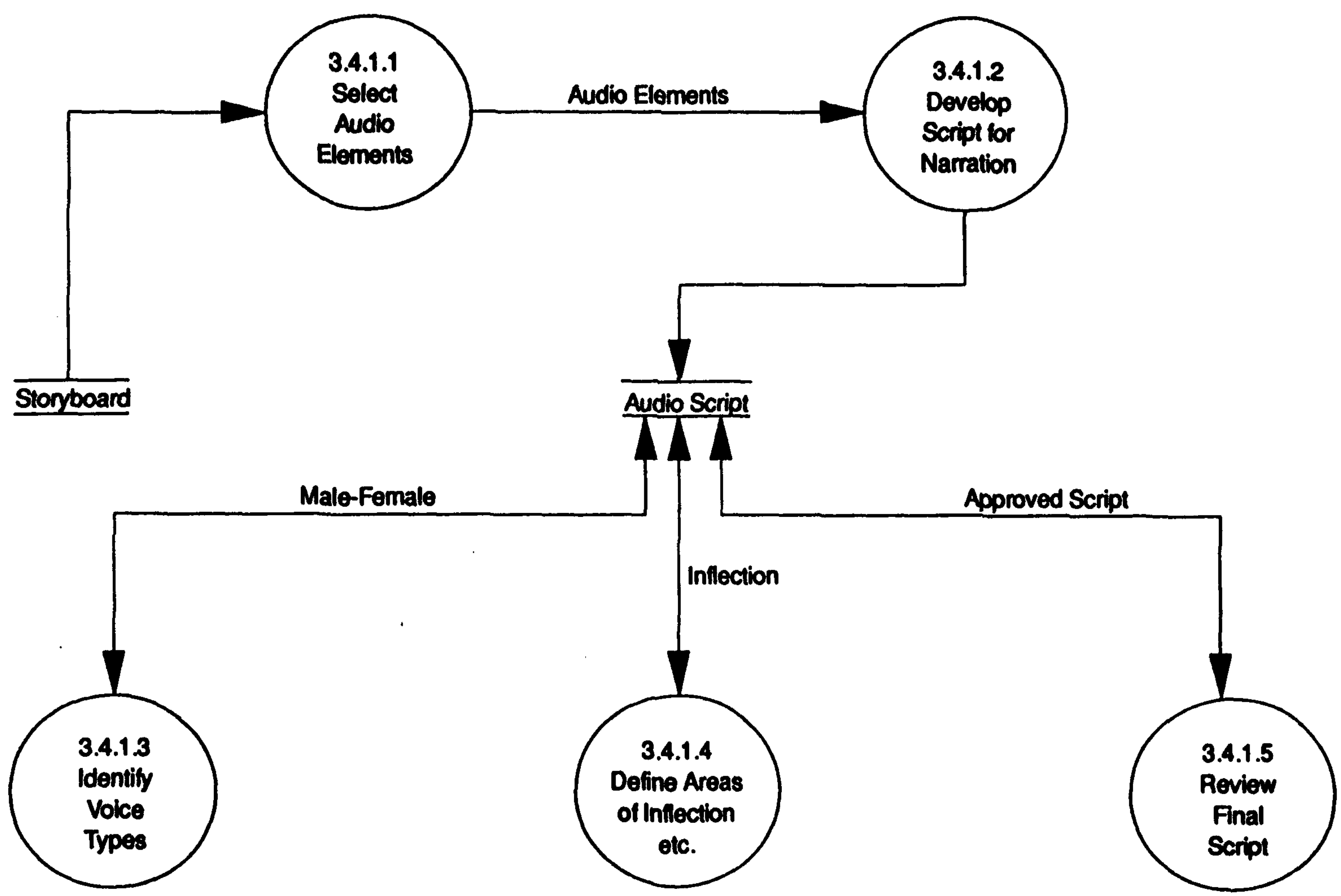


Figure 3.4.2: Develop Sound Effects/Music

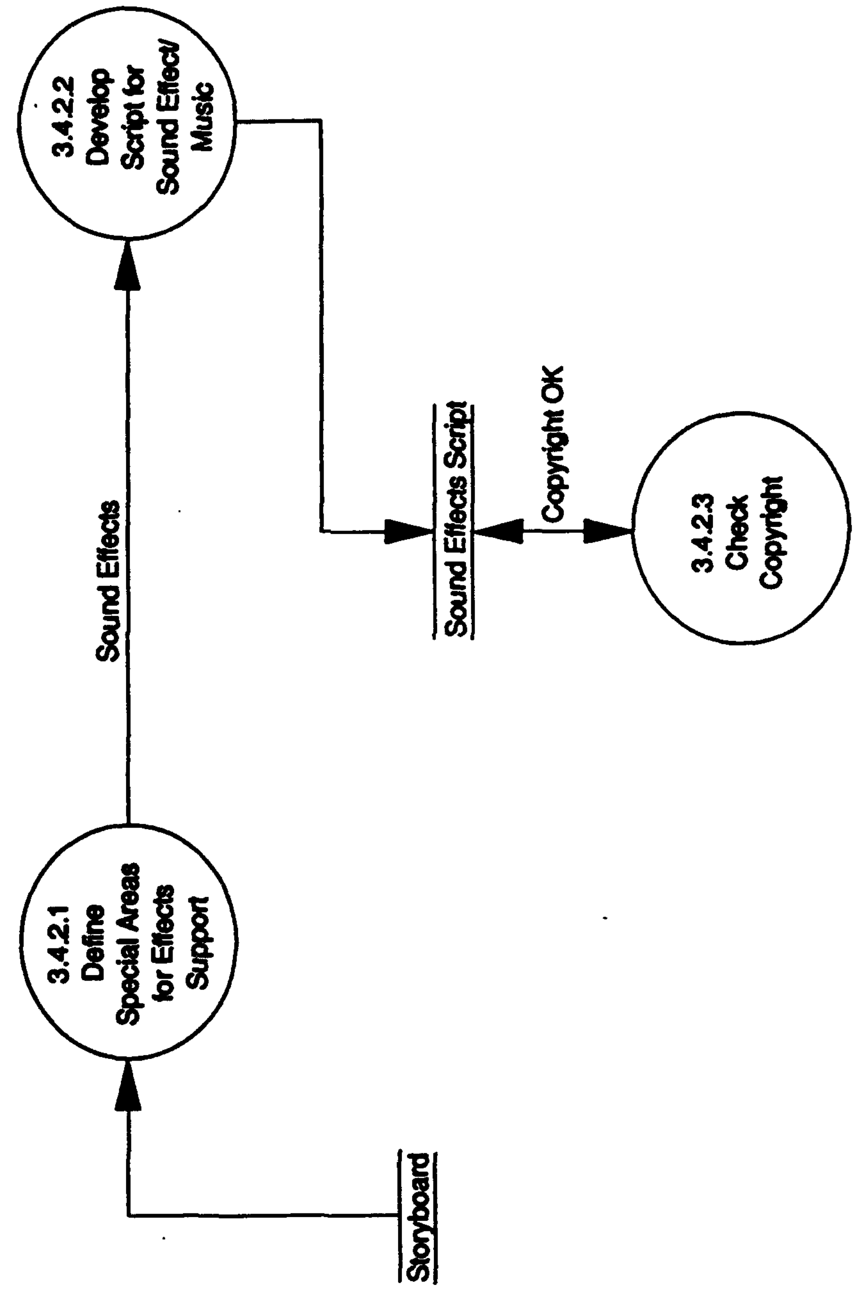


Figure 3.4.3: Develop Graphic/Animation

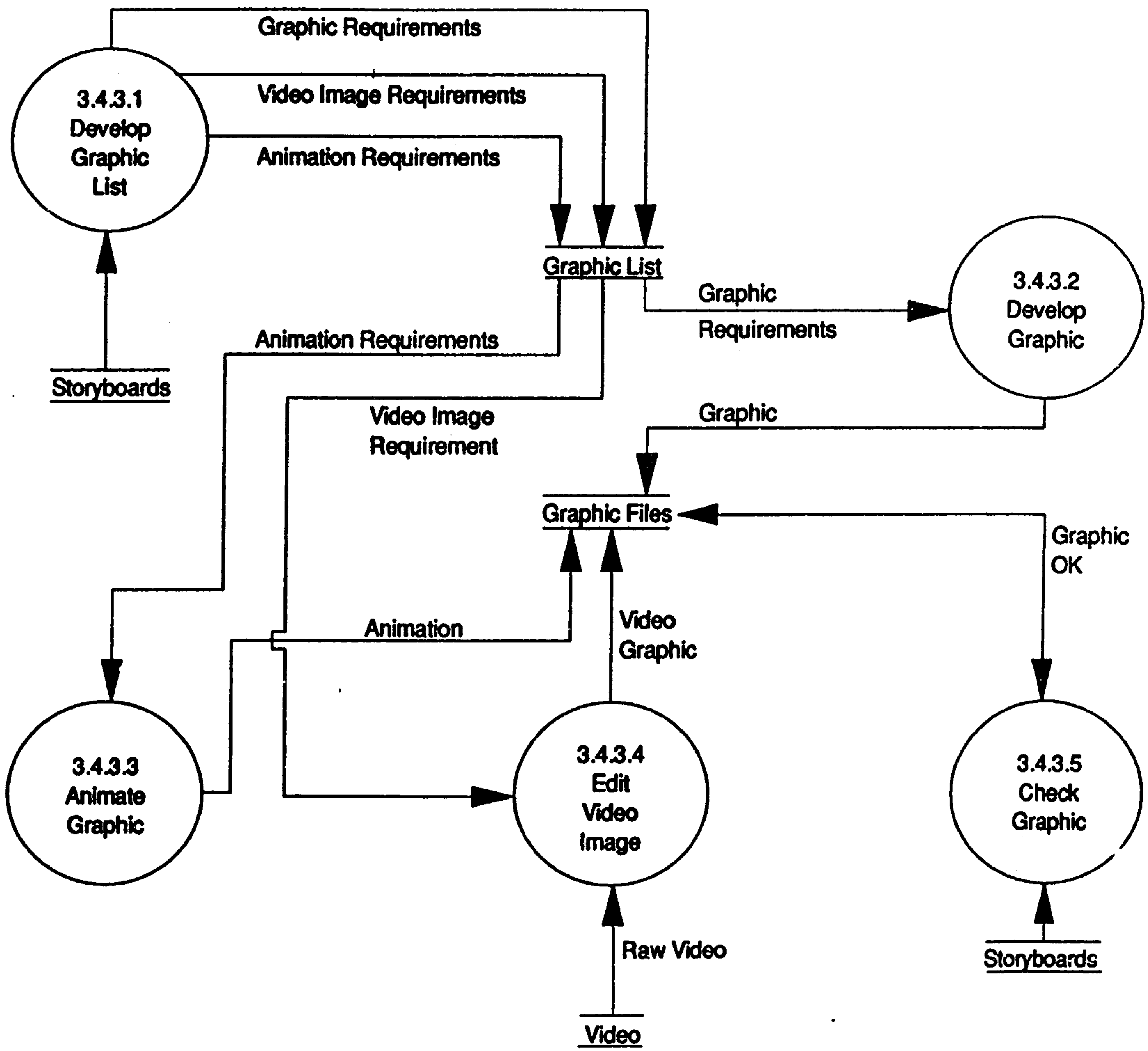


Figure 3.5: Multimedia Production

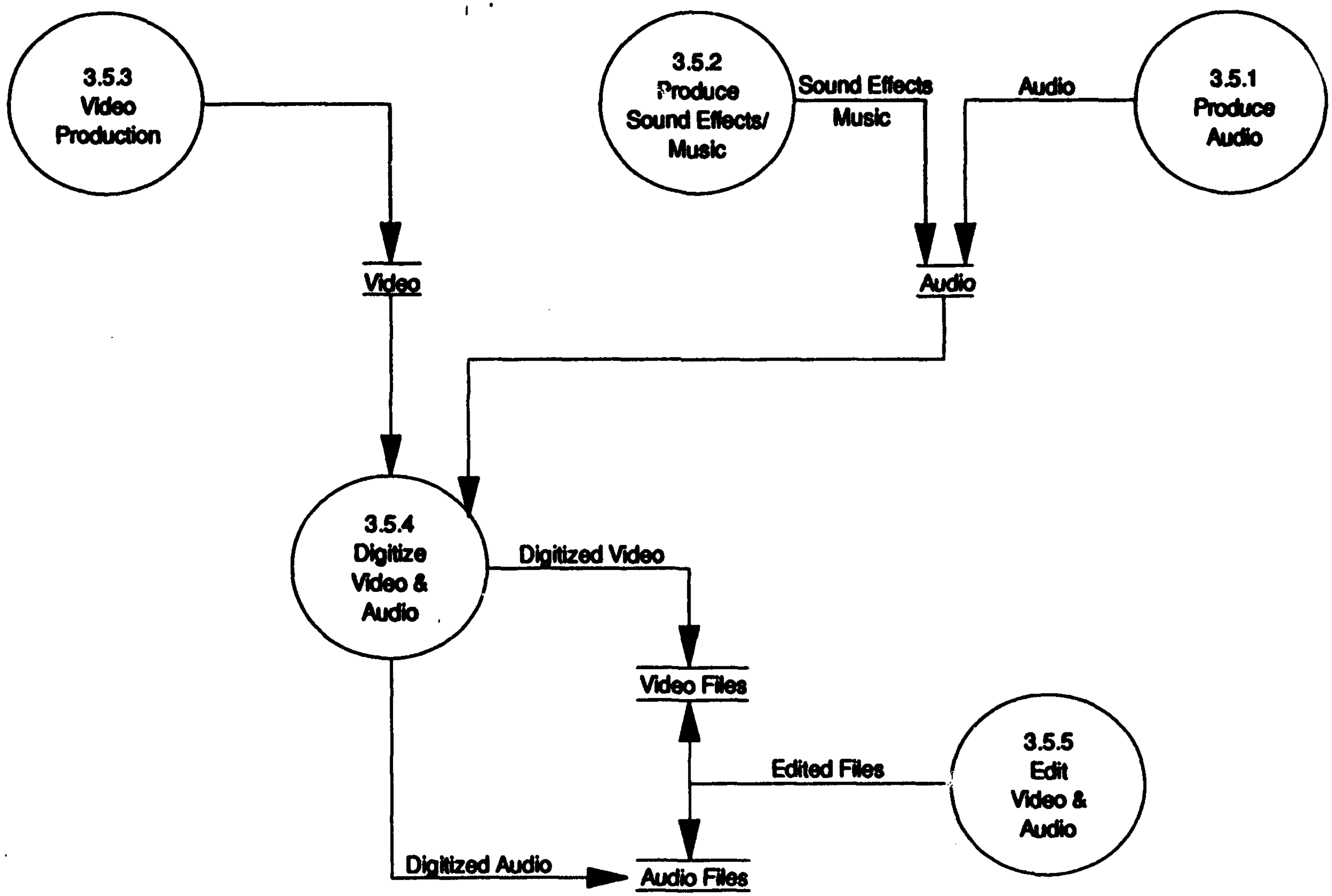


Figure 3.5.3: Video Production

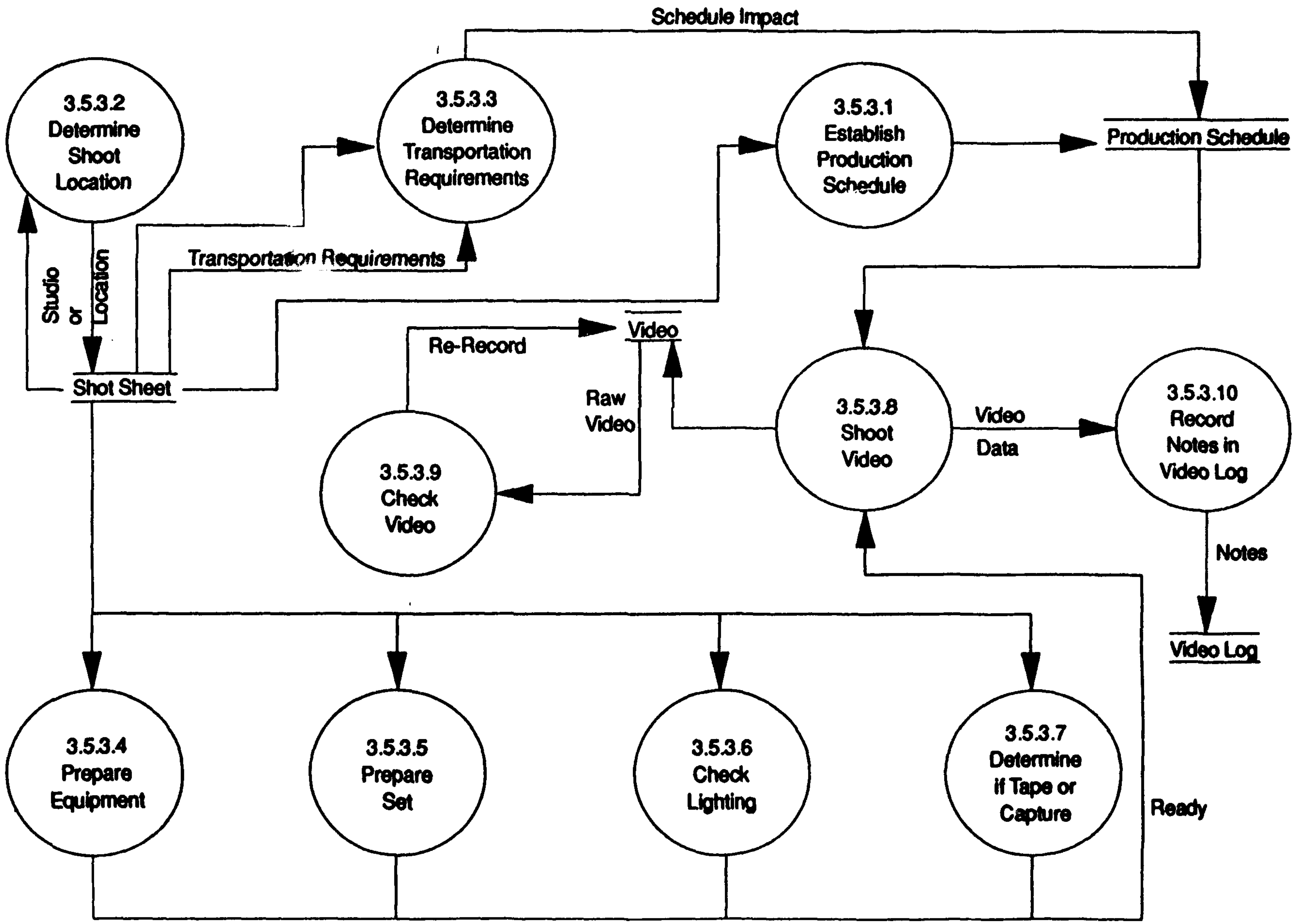


Figure 3.5.1: Produce Audio

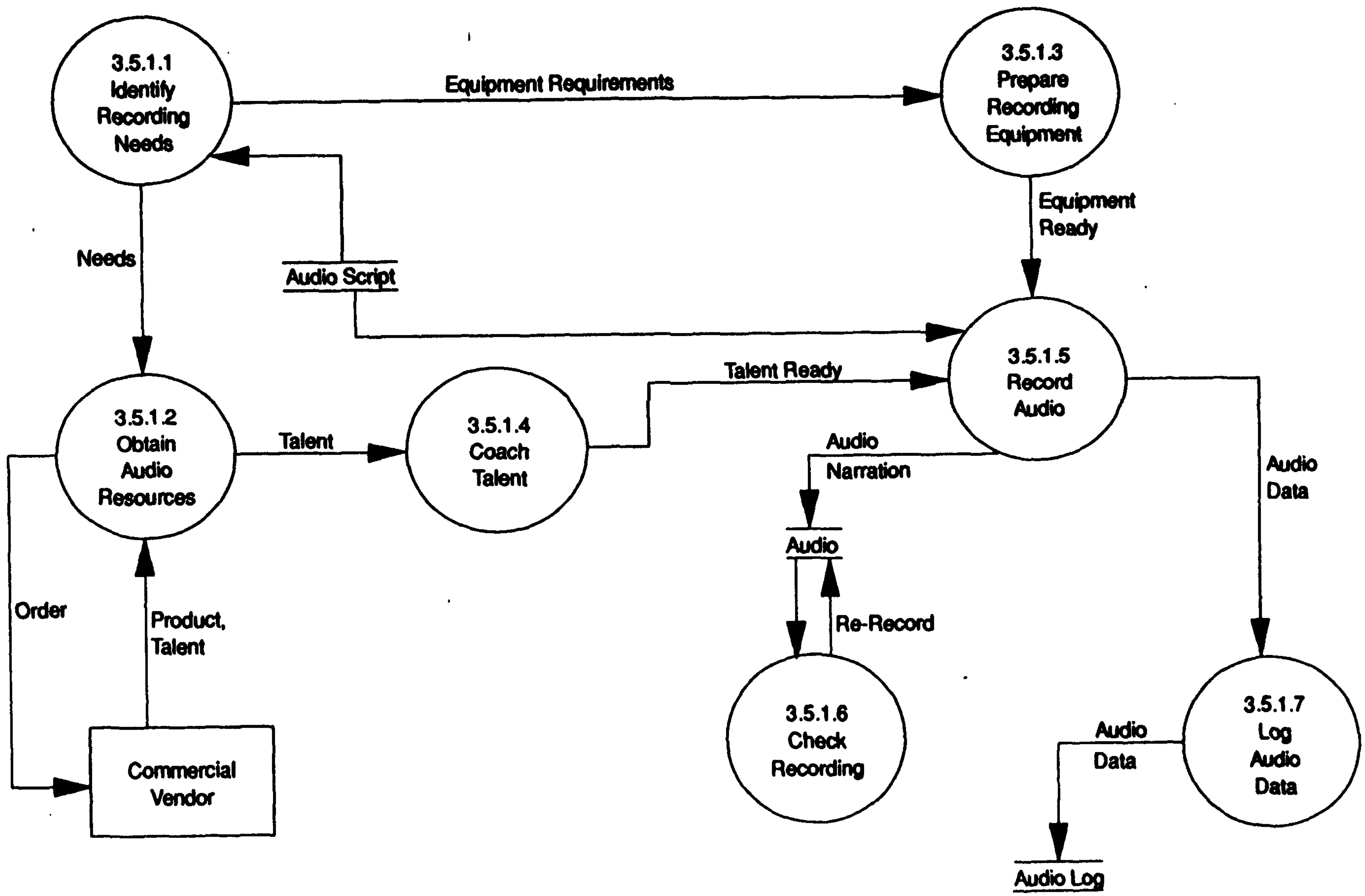
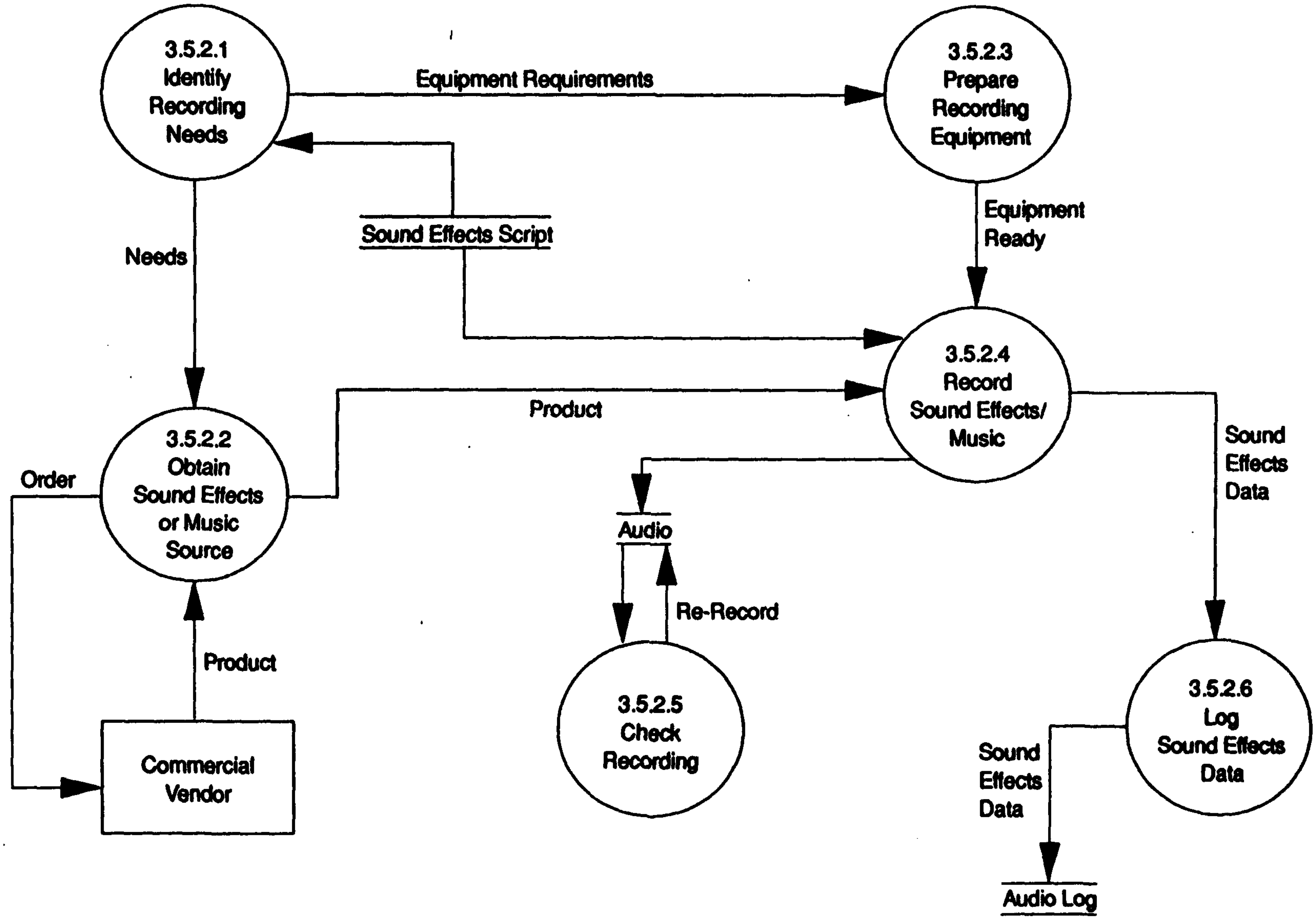


Figure 3.5.2: Produce Sound Effects/Music



PROCESS DESCRIPTIONS

NOTE

The numbering of each process description matches that used in the data flow diagrams. Whenever the description of a process conforms to traditional Instructional Systems Development (ISD), AFP 50-58 is cited as the source of information regarding the process. Recently that approach has been modified by AFP 50-68, but no attempt has been made to correlate each document or reconcile differences.

Process Descriptions

0. *Instructional Systems Development (ISD).* The standard Air Force and military practice for the development of training. See AFP 50-58, Volume I: Introduction, and AFM 50-2, Instructional Systems Development. In our model ISD has five sub-processes as listed below. Since multimedia development is almost entirely concerned with step 3 Develop Training, the model reflects it by expanding that node.

1. Analyze Training Requirements
2. Design Objectives and Tests
3. Develop Training
4. Implement Training Program
5. Evaluate Process and Products

1.0 *Analyze Training Requirements.* Training requirements analysis can be a multi-step process (see AFP 50-58, Volume II). While multimedia development does not normally affect the performance of most of these steps, there are considerations which should be taken into account because of multimedia capabilities. We have not listed these considerations here, although most can be found in the Lessons Learned and Critical Incidents sections of this report.

The multimedia development process begins with analyzing the training problem or conditions. The multimedia developer brings to the analysis phase his or her academic and personal background (including creativity) and previous experience with multimedia dev pment and training technologies. Documentation including a proposal, statement of work, and other customer-supplied documents provide an overview of the problem, status of current training, and proposed solutions. Extensive communication with subject matter experts (SMEs) is very important during this time. Two important documents produced during this stage are the statement of user requirements based on the training requirements analysis, and specification of the training system, derived from analyzing the requirements of operational needs. These play a major role in guiding the production of multimedia elements during all stages of ISD. The multimedia developer develops an overview describing the training system by listing concepts to be learned and how they will be portrayed. This provides the multimedia development team with a tool to define the scope and content of the system and serves as a basis for discussion with SME(s). The system requirements which need to be analyzed during this phase include hardware and software parameters. A milestone chart is also produced showing the different phases and goals of training development.

2.0 *Design Objectives and Tests*. The design of objectives and tests is not normally part of the multimedia process. The details of this process can be found in AFP 50-58, Volume III. When designing objectives and tests the capabilities of multimedia should be taken into consideration. Again, we have not detailed these considerations here. They may be found elsewhere in this report.

The design phase of a multimedia project encompasses interactive and content design, graphic and production design, software design, and instructional design. Using information from the SME obtained during analysis and specifications of the training system requirements, the instructional developer/multimedia developer plan the organization and appearance of the lessons. The multimedia developer uses his or her knowledge about the technical capabilities of the multimedia environment to design an effective student interface, and to present and test training concepts and scenarios. For example, the DVI training system can accommodate a one-quarter screen window to display full motion video to most effectively illustrate visual references. These ideas and strategies are reflected in storyboards which are produced during development. Multimedia elements for design include video, still image, graphic, audio, animation, music, and sound effects.

A multimedia developer accomplishes many traditional software development tasks. However, a critical trait of an effective multimedia developer is to view the project from a multimedia perspective. A multimedia perspective is defined as being able to apply the technical capabilities of a multimedia environment to the application's requirements. The developer should know general technical ramifications and the resources needed for its accomplishment. The multimedia developer needs to be creative, as well as have knowledge of interactive courseware design, interface or screen design, video, audio, graphics, and color selection. He or she should have a technical understanding of amount of time needed for development and resource allocation. During the design stage the multimedia developer has many opportunities to apply multimedia solutions, and to consider contingency solutions that support the constraints of time and funding.

3.0 *Develop Training*. The major activities of developing training are described in AFP 50-58, Volume IV. This model has elaborated the activities into 6 major processes which are normally performed in the development of interactive courseware as indicated below. The focus of the model is on 3.4 Multimedia Development and 3.5 Multimedia Production.

- 3.1. Develop Instructional Strategies
- 3.2. Select Media
- 3.3. Develop Storyboards
- 3.4. Multimedia Development
- 3.5. Multimedia Production
- 3.6. Validate Courseware

During development a script/narration document is developed which integrates the multimedia elements and provides the overview and sequence for the lesson. Finally, a lesson

prototype is constructed which provides a model from which subsequent lessons or frames are patterned.

3.1 *Develop Instructional Strategies.* Using the objectives and tests developed in the design phase, the instructional designer selects instructional strategies which most effectively present the objectives to the students. Instructional strategies are annotated on the rudimentary curriculum taking form with the objectives and tests. For a complete explanation see AFP 50-58, Volume IV.

3.2 *Select Media.* The instructional design team assesses the instructional strategies assigned to each objective and selects a presentation medium for the objective. Media models are normally used in selecting media. Cost and other considerations are taken into account in defining the media mix. It is highly beneficial for an experienced multimedia developer to provide input during media selection to capitalize on those visualization technologies which multimedia offers. Many objectives can benefit from multimedia and they should be identified here. For more explanation see AFP 50-58, Volume IV.

3.3 *Develop Storyboards.* Once media have been selected, storyboards are developed for those objectives designated for interactive courseware development. The instructional developer uses existing job or task data in the form of tech orders, job books, manuals, etc., and the input of SMEs, if the developer is not a technical expert, to develop a storyboard for the objective(s). Storyboards form the basis for further work during multimedia development and production. For more explanation see AFP 50-58, Volume IV.

3.4 *Multimedia Development.* During multimedia development storyboards are converted into interactive courseware. The multimedia development team uses audio and video files, and an authoring language or system to develop individual lessons. Selection of multimedia elements for production depends on the specific content and function of the lesson. Several factors are considered: 1) relative importance or prominence of the multimedia elements (for example, highest priority is assigned for producing full motion video if full motion video is required to teach critical concepts); 2) availability or stage of development of component materials; 3) availability of software tools and personnel, and; 4) overall complexity level (for example, if full motion video footage is required that involves lengthy or hard-to-schedule shots, it is scheduled early in production). The multimedia developer reviews training requirements, storyboards, and the script/narration to prioritize production of multimedia elements. The major activities of multimedia development are:

3.4.1 Develop Audio
3.4.2. Develop Sound Effects/Music
3.4.3. Develop Graphic/Animation
3.4.4. Develop Still Image
3.4.5. Develop Motion Video
3.4.6. Author Lesson
3.4.7. Define Standards

3.4.1 *Develop Audio*. Developing audio for multimedia consists of using the storyboards and standards to develop an audio script which can be used to produce the required audio. The major activities of developing audio are:

3.4.1.1. Select Audio Elements
3.4.1.2. Develop Script for Narration
3.4.1.3. Identify Voice Types
3.4.1.4. Define Areas of Inflection
3.4.1.5. Review Final Script

3.4.1.1 *Select Audio Elements*. The multimedia developer reviews the storyboard for a lesson to determine the specific audio elements required to support the instructional strategy. Audio elements required are highlighted. Audio elements can consist of the mainline narration for the lesson, voice effects for special purposes like help, narration of feedback, narration of optional materials, etc.

3.4.1.2 *Develop Script for Narration*. As audio elements are selected for use, they are developed into a narration script. In general, narration in multimedia applications, directs the student's mainline progress through the lesson. The script for narration should take into account common student errors and point them out. The multimedia developer should consider the use of text in addition to narration. Bulletized text can often be used to support a narrative script. The multimedia developer should develop scripts for positive and negative feedback, remediation and help. Each element of the storyboard may have several narrative components associated with it.

3.4.1.3 *Identify Voice Types*. The multimedia developer should decide whether to use a male or female voice, a single voice or a combination of voices and what purpose each type of voice serves. Each voice type has definite characteristics and advantages and disadvantages. The audio script should reflect the selection of voices and maintain consistency throughout the application in order not to distract the student.

3.4.1.4 *Define Areas of Inflection, etc*. The multimedia developer should specify on the narrative script areas of inflection, emphasis, and other special voice effects which are required to accomplish the lesson objectives. Individual creativity can be a major factor in the proper application of such features.

3.4.1.5 *Review Final Script*. When the narrative script is complete it is reviewed for correctness, to ensure complete content coverage, to make sure that proper language is used (i.e., in keeping with what the user is expecting), to make sure proper pronunciation is emphasized, and to ensure that all narrative elements support the lesson objectives.

3.4.2 *Develop Sound Effects/Music*. Sound effects and music contribute to the instructional effectiveness of a multimedia lesson. Sound effects are obtained from commercial vendors already recorded for use in other applications, or they are developed on location or in the studio. The major activities of developing sound effects and music are:

3.4.2.1 Define Special Areas for Effects Support
3.4.2.2. Develop Script for Sound Effects/Music
3.4.2.3. Check Copyright

3.4.2.1 *Define Special Areas for Effects Support.* The multimedia developer will check the storyboards to determine what sound effects or music are required. Some sound effects such as machine noise, alarm sounds, danger signals, etc. may be absolutely necessary in support of the lesson objectives. Some other sound effects or music may be aesthetically pleasing to the student, or they may enhance the lesson objective by promoting student attention. Each sound element should be selected based on a legitimate instructional reason.

3.4.2.2 *Develop Script for Sound Effects/Music.* As sound effects or music requirements are identified from the storyboards, a sound effects script is developed to catalog the various effects needed.

3.4.2.3 *Check Copyright.* When using commercially available sound effects or music, legal restrictions and copyright must be checked. If copyrighted material must be used, a copyright release or permission must be obtained. Caution must be exercised since royalties may need to be paid to some copyright holders.

3.4.3 *Develop Graphic/Animation.* The computer industry has been involved with graphics and its production processes before the advent of multimedia. New data are available and experience is being documented about 3-D graphics and animation production. Technical issues associated with the integration of digital images, video and graphics, 3-D graphics and animation are challenges for the multimedia developer. The integration of these capabilities is facilitated by a multimedia developer who has technical experience with the requirements needed for multimedia elements and the performance improvements of the new technology and PCs.

The multimedia developer always has new and advanced technologies and capabilities to choose from. The use of various multimedia capabilities provides opportunities to develop effective training applications. Animation provides a useful and effective visual aid, and newly affordable 3-D animation introduces further capabilities that could satisfy training requirements.

There should be a special effort dedicated to the production of the student interface. Production of the graphical user interface is accomplished by the use of a graphics or authoring software package. Most of the interface elements are produced in graphics or still image production sections. Production of the interface should evolve from brainstorming sessions with the user to produce an interface prototype, which can finally be integrated into a multimedia application. The multimedia development team may need to adjust or edit the interface in mid-development; it can be considered a living entity which is a direct extension of the user's requirements. The interface and the support for system navigation must support the user completely. The user should not have to spend much time figuring out how to use the system since an intuitive theme is usually more effective for training.

The major activities involved in graphic development are:

3.4.3.1 Develop Graphic List
3.4.3.2. Develop Graphic
3.4.3.3. Animate Graphic
3.4.3.4. Edit Video Image
3.4.3.5. Check Graphic

3.4.3.1 *Develop Graphic List.* The multimedia development team must be aware of the capabilities of the graphics package which is being used. Storyboards are reviewed to determine the number and type of graphics which need to be developed. If video images can be used instead of creating new graphic images, they should be identified. Still images which have not already been shot need to be added to the shot sheet. The multimedia developer must ensure that the video images to be used are in the proper format to be modified (cropped, cleaned up, etc.) by the graphics package. Graphics in the storyboards which will not utilize video images should be identified for creation. If graphics are to be used more than once in the application, they should be cataloged and each appearance noted. Whenever animation is required by the storyboards, the requirement should be annotated on the graphic list. Considerations which should be taken into account in determining to use a graphic or a video image, an animation or a motion video are: 1) instructional soundness of the approach, 2) ease of creation, 3) instructional effectiveness, and; 4) cost in resources.

3.4.3.2 *Develop Graphic.* The graphic artist should work from the graphic list and storyboards to create the graphic. The graphic software must be capable of the various formats required by the application. Graphics and images should be in a single color palette. Once the graphic is complete the file should be named according to conventions agreed upon by the multimedia development team. Finally, log the graphic.

3.4.3.3 *Animate Graphic.* The multimedia developer always has new and advanced technologies and capabilities to choose from. The use of various multimedia capabilities provides opportunities to develop effective training applications. Animation provides a useful and effective visual aid, and newly affordable 3-D animation introduces further capabilities that could satisfy training requirements. Animation production is very similar to that of graphics production. The graphic artist works from the storyboards and the graphics list to determine the type and level of fidelity (3-D, stick figure, etc.) required in the animation, and makes sure the animation software supports the application. The animation file should be named in accordance with the conventions agreed upon for the project. When the animation has been completed, log the animation in.

3.4.3.4 *Edit Video Image.* When video images are used it is frequently necessary to edit the image to meet the storyboard requirements. Raw video images (either still frame or motion video) can be used. The graphic artist and multimedia developer determine how the image selected should be edited to fit the application. The image may need to be cropped, re-sized, touched up, have adjustments made in the color palette, or other editing. When the graphic is

complete, the file is named in accordance with the project file naming conventions. Log the graphic.

3.4.3.5 *Check Graphic.* A quality control check should be made of each graphic created prior to inserting it into the application. When the programmer tests the graphic in the application it should be as ready as possible so that the multimedia lesson appears as near to the finished product as possible. If minor adjustments are required in the graphic, they should be noted and the graphic sent back to the graphic artist for correction. Log all actions in the graphic log.

3.4.4 *Develop Still Image.* The need for graphics can easily be supported or replaced by digital video's still image capability. Photo quality imagery is effective and can support an application's need for realism. Additionally, labor associated with graphic development is time consuming and costly. However, technical issues such as the size of the image, color palette compatibility, or editing time may require graphics instead. The capture (also called digitization), and editing (production) of still images is facilitated if the multimedia developer is aware of still image requirements during video shoots. Many images can be obtained cost effectively at these times. The cost effective planning and use of video production schedules, including setting up equipment, transportation, and local coordination of activities is essential.

3.4.5 *Develop Motion Video.* A shot sheet is a checklist of conditions for shooting new video footage. A shot sheet is developed by the multimedia developer for directing the video technician. Several resources, developed by the multimedia developer working with the SME during the analysis and design phases, are used to produce the list of required scenes for the lesson, including specific directions for shooting each scene. These resources include storyboards, user training requirements, and existing video. Existing video (often provided by the customer) is also reviewed for content and quality in order to plan which new video sequences are required. The shot sheet is designed with the video production schedule in mind since it specifies the cost, time, personnel, equipment, and other resources required to produce full motion video.

Design of the shot sheet is constantly checked in order to make sure that the directions for all the sequences are clear and complete. Alternative directions, such as trying out a different lighting arrangement in a scene, are also included. The multimedia developer also specifies in the shot sheet which still images and graphics are obtained from full motion video. This revised and edited shot sheet is ready to use by the video technician.

3.4.6 *Author Lesson.* Authoring/programming is the process of integrating the multimedia elements into the lesson, and includes all the technical specifications and functional descriptions from analysis, design, and production. This involves scripting, or writing programs to accomplish specific functions in the lesson. Working from the storyboards, script/narration, and shot sheets (or multimedia element lists), digitized/edited multimedia elements files are programmed into the training system. Problem solving techniques for software and hardware integrate the different components; knowledge about software and hardware capabilities and compatibility's is extremely important. Some editing or tweaking, a series of subtle adjustments to improve the system, is also performed during this stage. An example of tweaking is modifying

the justification of text in order to improve the appearance of a screen. The programming/authoring stage results in a complete programmed lesson integrating all of the multimedia elements, branching options and levels of interactivity, and instructional design. The lesson is now ready for customer review and testing.

3.4.7 *Define Standards*. At the beginning of the multimedia project the multimedia team should develop a set of standards that can be achieved within the scope of the software packages being used and in keeping with the requirements of the lesson objectives. Standards should be developed to determine file naming conventions, video formats used, color palette, scripting and storyboarding format, screen layout, text fonts, and all other aspects which affect the quality and consistency of the finished product. A standards document should be developed and provided to each member of the multimedia development team for use during the project. The standards document may be called a format guide, standard, or any other name which designates its purpose but it is a working document which must be accessible to all of the multimedia team members. Whenever standards do not serve the best interests of the training system, they can be changed, but ensure that later versions of a standard are retroactively applied to all of the courseware which has been developed to date.

3.5 *Multimedia Production*. The critical difference between traditional courseware development and that of multimedia development is production. Multimedia is composed of elements used by the movie, video, radio and television industries. These elements need to be designed and produced for use in the multimedia application. A multimedia developer can rely on industry professionals for the well-established and effective design and production techniques for these elements. The multimedia developer must understand the ramifications of using these elements on the computer in an interactive environment. What is effective on the large motion picture screen or even on the moderate size screens used for videotape viewing may not work well when presented on a computer monitor or within a window.

The delivery platform has inherent qualities which affect development of a training system. Good qualities of the delivery platform must be exploited in a manner that supports effective training while bad qualities must be avoided or worked around. Creative and technical flexibility are important qualities. It is at this point during development that the multimedia developer is able to make decisions *on the fly* that affect multimedia elements, training effectiveness, technical issues, and cost. Even though the multimedia developer may rely on industry professionals for their technical expertise, the responsibility for producing an effective training application is still the multimedia developer's. A basic knowledge of the user, subject, delivery environment, and learning theory must be applied during the design and production of each multimedia element.

The major activities of multimedia production are:

3.5.1 Produce Audio
3.5.2 Produce Sound Effects/Music
3.5.3 Video Production
3.5.4 Digitize Video and Audio

3.5.5 Edit Video and Audio

Identification of the multimedia elements for production originates during the multimedia development phase. Storyboards and scripts show where and how the multimedia elements are organized and integrated in the lesson. An overall production schedule is devised which describes in detail specific sequencing and step-by-step instructions for producing the individual multimedia elements: video, still images, graphics, animation, audio, music, and sound effects. Producing each multimedia element involves using the information from analysis and design, such as user training requirements, to ensure that the elements are used consistently and effectively within the lesson, for example, standardization of text location or an option box which gives students a choice about how to proceed. Storyboards and the script/narration are also used as the major documents to guide multimedia production, since they describe and display the content and organization of the lesson. Production includes digitizing (also called capturing) and editing the multimedia files so that they are ready for authoring or programming.

3.5.1 *Produce Audio.* The multimedia developer integrates audio, music, and special effects in an application to support audio and sound requirements. The production of the sound component of the multimedia application has specific technical issues associated with it. For example, if voice talent is used in the application, it should be realistic. The narrator should use a vernacular familiar to the user. Voices should be recorded at a constant volume level, and back ground noise should be completely eliminated. If both male and female voice talent are used, make sure both voices are being recorded at the same volume levels and that such serves a specific purpose. The production of the sound elements can go first to tape then to digital storage device, or directly to the digital storage device. In either case, it is important to log the data. The major activities of producing audio are:

- 3.5.1.1 Identify Recording Needs
- 3.5.1.2 Obtain Audio Resources
- 3.5.1.3 Prepare Recording Equipment
- 3.5.1.4 Coach Talent
- 3.5.1.5 Record Audio
- 3.5.1.6 Check Recording
- 3.5.1.7 Log Audio Data

3.5.1.1 *Identify Recording Needs.* The multimedia production team works from the audio script to identify the various components necessary for recording the audio narration, e.g., the number and kinds of voices to be used, what part each voice reads, inflection and voice modulation requirements, and other factors concerned with recording the narration. If additional resources are required obtain them prior to recording.

3.5.1.2 *Obtain Audio Resources.* If talent, microphones, special tapes, or other products are needed they should be obtained prior to beginning the recording session. Order(s) for the product(s) should be sent in time to ensure that the production schedule can be met.

3.5.1.3 *Prepare Recording Equipment.* Recording equipment should be checked prior to beginning the recording session. It is always advisable to test the recording equipment, microphones, studio acoustics, and other equipment with the talent who will be reading the narration. Special requirements should be tested to ensure they are ready for operation.

3.5.1.4 *Coach Talent.* All talent, whether experienced or not, will require some coaching prior to recording the narrative segments. Provide each voice talent with the portion of the script that you want them to read, point out places of emphasis, voice modulation patterns needed, inflection requirements, and how their portions may integrate with other voices and other multimedia elements. When the talent is prepared, try out the script once to make sure that they can read what has been written, and that what has been written in the audio script makes sense when read aloud.

3.5.1.5 *Record Audio.* The narration should be based on the audio script. If sections of the script do not sound like the script or storyboards had intended, make changes and record the changes on the script. While narration is most frequently recorded to tape first, then digitized, this is not always necessary. If the recording is not being done in a professional studio, care must be taken to ensure that extraneous noises do not interfere with the recording session. The narration talent should be located so that they do not have to strain or move in and out from the microphones. The recording equipment should be placed such that it provides a constant level of audio input from the speaker(s), unless stronger voice modulation is necessary (as indicated on the script).

3.5.1.6 *Check Recording.* Once the recording session has been completed, check the recording to make sure that it says what the script calls for, that it sounds natural and clear, and that no strange accents or pronunciation interferes with understanding. If there are problems with the recording, point them out to the talent and re-record on the spot until the problems are corrected.

3.5.1.7 *Log Audio Data.* After the recording session has been completed, record the pertinent information about each segment in the audio log.

3.5.2 *Produce Sound Effects/Music.* The major activities involved in producing sound effects and music are:

- 3.5.2.1 Identify Recording Needs
- 3.5.2.2. Obtain Sound Effects or Music Source
- 3.5.2.3. Prepare Recording Equipment
- 3.5.2.4. Record Sound Effects/Music
- 3.5.2.5. Check Recording
- 3.5.2.6. Log Sound Effects Data

3.5.2.1 *Identify Recording Needs.* The multimedia production team works from the shot sheet to identify the various components necessary for recording the music or sound effects. If the sound effects are to be produced by the team either at the work location or in the studio, the team must make sure that the equipment, tools and conditions necessary to produce the sounds will be

available during recording. If the sound effects or music to be recorded is not to be taken from live components, it will be necessary to obtain them from some source, e.g., record, tape, disc, etc. Any special recording equipment requirements should be identified and taken care of prior to setting up the recording session.

3.5.2.2 *Obtain Sound Effects or Music Source.* If music or sound effects are used from an existing source, the team must identify what music or sound effects are needed, which commercial source can provide that sound effect or music, and order the recording from a commercial vendor if a copy is not already available to the team.

3.5.2.3 *Prepare Recording Equipment.* Check to see that the right type of recording equipment is available to produce and record the sound effects or music. Check out the equipment at this time, i.e., prior to the first attempt at actual recording for use. If there is a problem with the equipment it should be taken care of prior to starting the recording session. When the recording equipment and sound effects production equipment is ready it is time to record.

3.5.2.4 *Record Sound Effects/Music.* The actual recording the sound effects or music should be based on the sounds called for in the sound effects script. As various sound effects segments are recorded the team should record pertinent information about each one, e.g., duration, brief description about what is recorded, start/stop locations, file or tape recorded on, etc.

3.5.2.5 *Check Recording.* A quality check should be performed on each segment immediately after it has been recorded. If there are problems, or if the recording does not meet quality standards, re-record it.

3.5.2.6 *Log Sound Effects Data.* As sound effects and music segments are recorded and checked, they should be entered into the audio log. Record pertinent information about each one, e.g., duration, brief description about what is recorded, start/stop locations, file or tape recorded on, special notes about the recording, storyboard to which it relates, etc.

3.5.3 *Video Production.* The multimedia developer must realize that the use of multimedia does not guarantee effective training, although creative use of video can be an essential element of a good training system. The multimedia developer must be concerned with the way video is shot, the size of the image that will appear on the computer screen, and potentially distracting movements of camera and subject. Technical considerations, such as size of digital video file(s), maintenance of digital files during development, and access to digital files in the application, are also other considerations. As digital video products increase in capabilities, editing software, compression, and fidelity and their effects on the application, are the main issues. For example, the availability of editing software allows for quicker and more cost effective updates to video used in an application allowing for more responsive development and a greater opportunity to satisfy user requirements (even as they change). Compression is usually associated with the size of the digital video file. As compression improves so does the amount of data that can be stored on a computer for an application. Currently, developers need to understand delivery system storage requirements and system performance as they design and produce for a multimedia application. Some applications are not candidates for digital video (or multimedia using digital

video) because the fidelity or quality requirements are not supported. As the fidelity of digital video improves so will the number of applications that it can effectively support.

The major activities of video production are:

3.5.3.1	Establish Production Schedule
3.5.3.2	Determine Shoot Location
3.5.3.3	Determine Transportation Requirements
3.5.3.4	Prepare Equipment
3.5.3.5	Prepare Set
3.5.3.6	Check Lighting
3.5.3.7	Determine If Tape or Capture
3.5.3.8	Shoot Video
3.5.3.9	Check Video
3.5.3.10	Record Notes in Video Log

3.5.3.1 *Establish Production Schedule.* Using documents produced during previous phases, such as the milestone chart, user and system requirements, storyboards, and narrative script, the multimedia developer establishes an overall production schedule which specifies a plan for each multimedia element. Planning includes estimating the cost, amount of time, materials and personnel required to complete each production process.

3.5.3.2 *Determine Shoot Location.* Several variables, such as subject matter, lighting, facilities, and equipment are considered when selecting a studio or location shoot. It is usually preferable to use a studio since the environment can be controlled; however, it is not always cost-effective, practical, or realistic (e.g., planes flying). In some cases, legally binding permission must be obtained before shooting, if shots involve shooting at a private facility. For both studio and location shoots, lighting requirements are evaluated to enhance visibility, visual depth and attractive shots.

3.5.3.3 *Determine Transportation Requirements.* If video shooting is to be done on location or even at a studio and transportation must be provided for equipment and other props, these arrangements should be made far enough in advance so as not to hold up any of the other production activities. Transportation to a location may seem like an insignificant part of the overall video production effort, but without it all other production work may not be possible.

3.5.3.4 *Prepare Equipment.* The multimedia development team needs to work as cost effectively as possible. The faster the team works to get everything into place the cheaper the shoot will be. When a professional video production crew is used, the clock is always running. In fact, the saying "time is money" applies to all parts of the multimedia development process, no matter which personnel are involved. Camera, tapes, props, monitors, and other video production equipment should be itemized and ready prior to arriving at the location or studio so that production will not be held up waiting for all the elements to be assembled.

3.5.3.5 *Prepare Set.* When shooting on location all of the tools and equipment for producing the video, and those which are to be included in the video should already be on the set. Check to make sure that these are ready and in working condition prior to the recording session. For example, things can be overlooked such as equipment which needs to be warmed-up for several hours prior to use. These seemingly insignificant considerations can lead to costly shooting delays. Even when shooting on location it is necessary to prepare the set. Equipment may not be in the best location for shooting, i.e., lighting may be poor, or there may not be enough room for camera and lights to be positioned properly. Check shooting locations prior to conducting the shoot; if necessary arrange for changes to be made prior to the scheduled shooting time, then check the location again. When shooting in a studio or other controlled environment all equipment necessary for the shoot should be assembled and checked out to ensure it is ready to shoot. Locations may need to be marked off for equipment, props and talent with chalk prior to the scene being recorded. If the set can not be ready in time, it may be advisable to postpone the shoot to some other time rather than waste the time of all the principals involved.

3.5.3.6 *Check Lighting.* Lighting must be checked to ensure that all elements mentioned in the storyboard are visible to the proper level of fidelity. Lighting in the studio can be controlled by using reflectors and various lighting techniques to ensure that the right effect is achieved. When shooting on location lighting conditions of natural light must be understood and taken into consideration in planning the scene. Overcast skies provide different lighting conditions than direct sunlight. Talent may have to be placed in different locations because of sunlight which is directly in their eyes. Lighting must be checked to ensure that all objects in the scene are clearly visible and without glare. If glare is present, techniques must be employed to reduce or eliminate the effects of glare. Shadows also pose a problem. Care should be taken to ensure that shadows do not detract from the desired effect for a scene.

3.5.3.7 *Determine If Tape or Capture.* There are special conditions a multimedia developer should be aware of when digitizing and storing images on the hard drive. Using the storage capabilities of digital media creates a flexible environment for image capture. Various conditions can be demonstrated and experiments may be performed, the results of which can be viewed immediately in the application. This is an opportunity that should be exploited by the developer in order to allow the user to see and make decisions in a tangible way. Capturing images directly onto the digital storage device or large hard drive must be done in a controlled environment. An image log which contains descriptive notes and characteristics of the image is helpful. Other special conditions include capturing in the same color palette, at the same aspect ratio, and with lighting and support colors that are consistent with the interface.

If the multimedia developer decides to use tape before capturing into the digital environment, he or she must consider these conditions: logging, location, notes, lighting, and planning for the digitizing or capturing process. During this process, the issues to be concerned about are similar to those issues of capturing directly to digital storage device.

3.5.3.8 *Shoot Video.* The video shoot is based on three documents-- the video production schedule, the edited shot sheets, and the storyboards. First, a production schedule is constructed which considers logistics such as location, transportation, and permission, if required.

Equipment is tested to make sure everything works; supplies are checked. If required, personnel are coached about their roles. Conducting a practice run-through video shoot helps to reduce shoot time, since problems can be identified and corrected. After shooting new footage, the multimedia developer confirms on an updated shot sheet that the scenes are complete (or if scenes need to be re-shot). The updated shot sheet also includes extensive notes on the scene-by-scene results of the video shoot.

3.5.3.9 *Check Video.* While recording the video, prior to moving on to the next scene, the multimedia developer should check the video to ensure that it meets standards and accomplishes the results indicated in the storyboards. The best way of checking this raw video is to view it on a screen. The developer views the video for content accuracy, conformance with standards, and general appearance if discrepancies are noted the multimedia developer should point them out to those concerned so that they can make corrections and re-shoot the video. After the video has been recorded a quality check should be made to ensure that everything indicated in the shot sheet and storyboards has been accomplished.

3.5.3.10 *Record Notes in Video Log.* During video production notes should be kept about video data such as length of segments, location on the tape, number of tapes recorded, and other such technical factors. After all video production has been completed the notes should be assembled and any annotations made as necessary.

3.5.4 *Digitize Video and Audio.* Digitization is the process of converting an analog signal into a digital signal, also known as capturing. All multimedia elements except for those produced within the computer, are digitized before being integrated into the training system. The multimedia developer works from the multimedia elements list to produce a digitization schedule and a digitization sheet with updated file name, number, size, and location information. The digitization sheet and schedule are used to organize and guide digitization activities and to monitor the status of the multimedia elements.

It is preferable to digitize before editing. A digitization schedule lists the steps which must be accomplished along with how long each of them will take. A digitization sheet is produced from the revised shot sheet containing information about the description and location of the tape segment, its quality, exact length, and its destination, for both existing and new full motion video footage. Software capture modification can also be used to digitally change values of the images.

3.5.5 *Edit Video and Audio.* Editing is the process of altering or otherwise improving the appearance or organization of the multimedia elements. An example is standardizing the fades and transitions between full motion video clips in a way that enhances the appearance of lesson frames and also does not distract students. The multimedia developer needs to edit each of the multimedia elements in the training application in the appropriate location, for example, by matching narration with full motion video clips and text in a particular lesson frame. Maintaining extensive and precise documentation in the form of storyboards, and the narrative script throughout this process, facilitates editing by illustrating the placement, sequence, and rationale for editing each element. The digitization sheet is used for tracking the multimedia

elements. As each file is edited, a new edit list is developed which describes the modification and new location of the file for authoring/programming purposes.

It is preferable to edit digitized video, although some editing may occur prior to or during digitization. The most critical step is to construct the edit video list (which is the same as the edit decision list for analog edits) which specifies edit activities. The video is reviewed and if the quality is not acceptable, the multimedia developer may want to re-digitize. In some cases, fades and transitions may be added during digitizing. An updated video log is produced. Edited video segments or clips are ready for programming/authoring according to an updated video log.

The editing process is a significant part of developing a multimedia application. The multimedia developer however, can often rely on professionals in the industry to accomplish the editing requirements for some multimedia elements. However, the multimedia developer first needs to edit each of the multimedia elements into the application in the appropriate location. This reinforces the need for comprehensive documentation during the development and production stages. The multimedia developer needs to determine the effectiveness of each multimedia element. If the training requirement has not been met, the developer must ensure that re-design and further production is accomplished to meet those needs.

3.6 *Validate Courseware.* Interactive courseware is evaluated for consistency, correctness, ability to teach the objectives, and other factors during formative evaluation. If problems are detected in the courseware, they are noted and revisions are made to the courseware as indicated by the evaluation plan. For more explanation see AFP 50-58, Volume IV.

Testing and validation is performed by users who are experts in the various domains represented in training. This includes a review of content, system navigation, and overall appearance and feel of the lesson in accordance with the storyboards and script/narration. The customer approves the final screen design or indicates corrections or other suggestions for improvement. After these revisions, the lesson is ready to be implemented in the training environment.

4.0 *Implement Training Program.* While multimedia can have some effect on the implementation phase of a training program, the basic steps remain unchanged. For an explanation of the implementation phase of ISD see AFP 50-58, Volume V.

5.0 *Evaluate Process and Products.* The steps performed in training evaluation can be found in AFP 50-58, Volumes IV and V. Multimedia imposes additional requirements on the evaluation process since it makes use of new visualization technology to deliver instruction and assess student performance, and interjects different development steps into the ISD model.

DATA DICTIONARY

Data Dictionary

Air Force commands:	Users of the products of training organizations. The commands received trained personnel, graduates of courses, to perform their mission(s). After a period on the job, commands provide field evaluation data on the graduates they receive.
Animation requirements:	Elements of the storyboard which can be achieved by animation sequences rather than by other means such as simple graphics, still image video, or full motion video.
Animation:	Placing several graphic segments together to a produce motion sequence.
Approved lesson:	Lesson has been accepted for approval by the customer; lesson is ready to be implemented.
Approved script:	Once the script has been reviewed it is either sent back for revisions or approved for use as is.
Audio data:	Information regarding the recording of audio either narration, music or sound effects.
Audio element:	Elements of the storyboard which can be achieved by audio sequences rather than by other means such as text, sound effects, music, video or graphics..
Audio files:	Storage location for digitized audio.
Audio level:	Specification of standard for audio level.
Audio log:	Database of information regarding audio and its recording activities. Includes such audio data items as lesson or storyboard to which segment(s) or entire tape relates, recording segment size, i.e., running time, what is recorded on a tape, location of segment on the tape, and other such pertinent information.
Audio narration:	Narrative produced by the talent in accordance with the audio script. It is normally recorded onto tape for later digitization and overlay onto video segments.
Audio script:	Document which controls the production of audio. Lists the storyboard from which a segment is derived, and the actual narration, sound effects or music required.

Audio: Sound effects, music or narration sequences used in producing a multimedia lesson.

Color: Specification of standard for color.

Commercial vendor: Organization which provides a product or service needed during the production of multimedia elements.

Copyright OK: Indication that the sound segment being used has no copyright or that a copyright release has been obtained.

Customer comments: Customer provides list of comments regarding final screen design during testing and evaluation; after revision, lesson is ready for implementation.

Digitization schedule: A schedule for digitizing (e.g., converting an analog signal into a digital signal) multimedia elements, listing the steps which must be done and how long they will take, is produced from the multimedia elements list.

Digitization sheet: The digitization sheet is produced from the multimedia elements list; for each multimedia element the list contains the file name, file number, file size, and file location, and information about quality.

Digitized audio: Narration, sound effects or music which has been converted to digital format.

Digitized video: Video which has been captured by a digitizing or capture routine for use as a digital file rather than in traditional analog format.

Edit list: This list, produced after files are digitized, describes the placement, sequence, and rationale for editing each multimedia element.

Edited files: After video and audio have been digitized they can be edited in various ways by splicing segments together, overlaying audio tracks on video segments, re-ordering segments, etc.

Edited shot sheet: Original shot sheet is edited and revised to ensure that directions for shooting new video segments are clear and complete.

Equipment ready: Indication that all equipment needed for a recording session is ready to operate as specified in the audio or video script.

Equipment requirements: Either audio or video equipment required for a recording session. This may also include other equipment such as machines or tools from the job which are to be used in the segments being recorded during the session.

Existing video: Video resources are provided by the customer, obtained from a clip library, or other source; if quality is acceptable, may reduce need for shooting new video.

Feedback: Data uncovered by the evaluation process which can be of use in tailoring or modifying the various other activities of ISD.

Field evaluation data: Data from various Air Force commands which indicates the quality of the graduates of training programs provided to them. Schools can infer as to the effectiveness and efficiency of their programs based on this feedback.

Full motion video: Video segment which depicts some activity or function using motion as a component of the scene. In contrast to still image video or graphic without animation.

Graduates: Students who have completed some course of instruction successfully. They normally report to some major Air Force command upon completion of the training course.

Graphic files: Storage location for graphics.

Graphic list: Contains graphic requirements, video image requirements and animation requirements. The graphic list is used in developing each of these elements.

Graphic OK Indication that the graphic being used has been checked for conformance with project standards.

Graphic requirements: Specific graphics required by a storyboard. All graphic requirements are entered into the graphic list.

Graphic: A picture or other depiction created with standardized software packages. All graphics are developed from storyboard requirements and stored in graphic files.

Hardware/software: Computer hardware and software (configuration) requirements for the training system are often specified by the customer; for example, working within a particular operating environment, or using a special authoring tool.

Inflection:	Specific areas of narration in the audio script where the talent is directed to provide some voice inflection or other characteristic to help achieve the learning outcomes specified in the objectives.
Instructional design:	Structural and functional framework for presenting and evaluating instructional objectives in the training system.
Interactive courseware:	Computer-based training lesson materials. It may consist of digitized video clips, interactive videodisc segments, CD-ROM portions, graphics, some type of student administration module, and the software and programs necessary to run the lessons.
Job/task data:	Job and task analysis information, tech orders and manuals, job books, and other materials which tell how to perform the tasks associated with a particular job. Customer provides documents about subject matter, current training, student characteristics, photographs, video, and other relevant materials for analysis of user and training requirements.
Lesson prototype:	Developed early in the project, this is an original model of a frame or lesson from which subsequent frames or lessons are patterned.
Lesson:	A complete interactive courseware component which is normally accomplished by a student in one sitting. It may include multimedia elements.
Male-Female:	Type of voice talent to be in a narration.
Milestone chart:	Schedule which lists major phases and goals along with their estimated time allotted for completion.
Multimedia elements list:	Using the storyboards and script/narration, multimedia elements are categorized according to type (i.e., graphic, still image, etc.) and specifies their file name, file number, size, location, and other features.
Music:	Pre-recorded music which can be used in an application instead of producing original music.
Needs:	Audio, video, equipment, talent or other items needed for a recording session which are not available. These items must be obtained from a commercial vendor.

New video footage: After reviewing existing video resources, the multimedia developer specifies new video footage which is required for producing the lesson.

Notes: Video data and other information about a recording session which are recorded in the video log.

Objectives & Tests: Criterion objectives and the test instruments which measure objective accomplishment (see AFP 50-58, Volume III).

Order: Purchase order to a commercial vendor for some item needed during a recording session.

Product: Item(s) provided by a commercial vendor per purchase order.

Production schedule: Schedule for the production of video and audio for an application. The schedule contains the items to be produced, when the production takes place, how long production activities last, resource requirements, and any other pertinent information. This plan, includes estimates of cost, time, materials, and personnel required to complete each production process.

Programmed lesson: All components of lesson have been programmed; lesson is ready for testing.

Raw video: Video which has just been recorded; no editing has taken place.

Re-record: If a segment is not correct or does not meet standards it must be re-recorded.

Ready: Indication that the equipment, set, camera, lighting, format and other aspects of a recording session are in place and prepared for the shoot.

Revisions: Changes or modifications required in interactive courseware based on the results of courseware validation activities.

Schedule impact: What effect transportation requirements may have on the production schedule.

Script/narration: A document which contains the segments recorded by the narrator in addition to specific directions on how segments are to be read and what other multimedia elements accompany each segment.

Shot sheet: Describes the number, type and location of the various video shots which must be recorded during production.

SME's comments: The subject matter expert (SME) provides comments on the application's content and interactive design, graphic and production design, hardware and software requirements, and instructional design.

Sound effects data: Information regarding the recording of sound effects or music.

Sound effects script: Script which specifies the music or sound effects necessary for the storyboard(s).

Sound effects: Specific areas of the audio script where special sounds or music must be provided to help achieve the learning outcomes specified in the objectives.

Standards: Specifications for the format, appearance, files and other aspects of the lessons. These specify the minimum acceptable standard for the item.

Still image: Video produced specifically for showing details without motion, i.e., single frame of video is used for each function or element depicted.

Storyboards: Produced during the development phase of ISD to describe the content and approach taken during the development of interactive courseware lessons. Consists of sequences of rough sketches that show key frames of the structure and content of the lesson at different stages.

Studio or location: Location where recording of video sequence takes place; either on location at some job site or in a studio where the environment can be controlled.

Talent ready: Talent has been coached and is ready to record the segment.

Talent: Voice, sound effects or music provider; may be from the same organization or from some commercial vendor.

Training course: The product of training development activities. Consists of curriculum materials, hardware and software, interactive courseware, student materials, instructor materials, and other elements used to train.

Training requirements: Product of the analysis phase of ISD (see AFP 50-58, Volume II).

Transportation requirements: Need to transport personnel and/or equipment to a location or studio for a recording session.

Video data: Information regarding the recording of video either on tape or directly into a digitized format.

Video files: Storage location for digitized video.

Video format: Specification of standard for video format.

Video image requirements: Specific video images required by a storyboard for development into graphics. All still image requirements are entered into the graphic list.

Video log: Database of information regarding video and its recording activities. Includes such video data items as file names, file size, scenes recorded on a tape, location of scenes, and other such pertinent information.

Video: Still images and full motion video used in producing a multimedia lesson.